AN ANALYSIS OF THE POLYGRAPH'S ABILITY TO DETECT DECEPTION IN CRIMINAL INVESTIGATIONS AND HIRING

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Abstract

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Statement of the Problem

The detection of deception has long been of great importance to law enforcement in both criminal investigations and in the selection process for new officers. The federal government also utilizes tests for the detection of deception for new hires as well as periodic re-screening of individuals in sensitive positions.

The polygraph, which purports to detect deception by the measurement and scoring of physiological changes of the examinee during questioning, is the most commonly utilized method for detecting deception. While the polygraph is utilized by most law enforcement agencies and federal entities, there exist many doubts in the scientific and legal fields as to the accuracy and validity of the testing process. Opponents of the polygraph state that the over-reliance on the unproven abilities of the polygraph in detecting deception leads to serious security risks and potential miscarriages of justice.

Methods and Procedures

Data from existing studies will be used to develop a recommendation regarding the use of the polygraph in its varying forms for both the use in criminal investigations as well as in the screening of applicants and current employees. An examination of possible alternatives will also be undertaken. This examination will consist of the review of the alternative technologies and the studies regarding their accuracy and validity.

Findings

It was found that the traditional polygraph in its most utilized formats, the Control Question Test (CQT) and Relevant/Irrelevant Test (RIT), was found to be lacking in scientific validity with little to no quality research having been conducted to test the underlying concepts. The remaining format, the Guilty Knowledge Test (GKT), has been shown to be a more reliable and valid indicator of deception. The GKT format has been more scrutinized making it appear to be a much more suitable test for criminal investigations than the other formats. However, the GKT format is not suitable for use in the screening of applicants and current employees, which is the highest percentage use of the polygraph.

A recommendation has been made to continue the use of the GKT format for use during criminal investigations. The CQT and RIT formats have been found to have "utility" as a prop

for eliciting confessions of wrong-doing when used in both screening as well as in criminal investigations. While the utility of the polygraph to elicit these confessions serves a very useful function, most agencies place too much faith in individuals who have "passed" the polygraph. The overreliance on the polygraph has the possible effect of neglecting other forms of investigation and background checks which could uncover more reliable information.

The CQT and RIT formats may have a second life as new technologies being tested may work to further refine these formats or may be used in a fusion of technologies to better determine the truthfulness of examinees. These new technologies may also supplant the traditional polygraph as many of the new methods resist manipulation by the examinee. These alternatives are also amenable to automation which removes human interpretation and influence on testing, both of which are two major areas of concern in testing for deception.

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I. INTRODUCTION

Statement of the Problem

Since the beginning of human history, lying has been utilized by humans for both personal gain and for avoiding the consequences of their actions. According to Livingstone Smith (2004) "lying is a fundamental aspect of human behavior" and it likely emerged early on in the evolutionary history of humans. Persaud (2005) stated that our ability to deceive begins as children when we become self-aware as indicated by self-recognition and self-conscious emotions. Concurrent with humans' development of lying, both society and the sciences have attempted to develop methods for the detection of deception. While methods have progressed from the crude trials by ordeal, such as holding a mouthful of rice during a prosecutor's speech in ancient China or swallowing a slice of cheese and bread in medieval England, to the most recent computer-analyzed devices, the detection of deception has largely relied on interrogation and simple psychology to elicit the truth (Ventreli & Simon, 2012). What stands unproven is whether modern science has developed methods for detecting deception that are any more accurate than those utilized in medieval times.

The polygraph, a machine designed to differentiate truth from deception using feedback from the body, has become the most widely utilized method for detecting deception. In fact, it is a required component of the hiring process for local, state, and federal law enforcement agencies. The polygraph is also heavily relied on in federal government agencies, most visibly by the Department of Defense (DoD) for investigations and the Department of Energy (DoE) as part of the hiring and periodic re-testing of employees in sensitive areas of the atomic energy industry (Cumming, 2009).

Having trustworthy employees working in law enforcement as well as in sensitive areas in the federal government ensures that communities can have faith in these agencies. The proper vetting of employees who have access to sensitive information can lessen the chance that this information will be passed on to other governments or rogue actors. Misplaced reliance on methods of detecting deceit among potential and current employees presents an enormous risk. Due to the nature of the risk posed by having untrustworthy individuals in positions of power or in control of classified information, it is imperative that only valid and reliable methods are used in the screening of these individuals.

Along with its use in the screening of applicants, many law enforcement agencies use polygraphs during criminal investigations. Although generally not admissible in a court of law, polygraphs are frequently used by investigators to either focus on an individual or to exclude them from further investigation (Grubin & Madsen, 2005). Accuracy and reliability are paramount in these circumstances due to the threat posed by the potential loss of liberty for the innocent individual who fails in testing or the guilty individual who is released into society to reoffend.

Purpose of the Study

While the polygraph is the most widely used method of detecting deception, there exist many doubts in the scientific community regarding the validity of polygraph testing. One of the most frequent arguments against polygraph testing is that it has not developed a base of knowledge that meets rigorous scientific standards, and that it has largely been developed outside of academia (Meijer & Verschuere, 2010). Other methods of detection that researchers hope are more accurate and less prone to manipulation are in use or in various stages of development. Voice Stress Analysis, the analysis of verbal statements based on the assumption that the voice

changes under the stress of deception, is currently in use in some settings (Hollien & Harnsberger, 2006). In addition, the analysis of micro-facial expressions and functional Magnetic Resonance Imaging (fMRI) of the brain are also being developed.

Significance of the Study

The detection of deception takes on added importance in law enforcement where the authority vested in law enforcement officers is so great that any abuse of the power can have significant implications on the constitutional rights of an individual. The detection of deception can be broken down into four main areas in law enforcement; the screening of potential new hires, periodic screening of employees in sensitive positions, testing for concealed information in criminal investigations, and testing as part of a treatment program for offenders. The need for accurate, reliable, and valid tests is of vital importance. Errors in testing could have profound consequences for the test taker, the organization relying on the test, as well as society.

Persaud (2005) stated that humans generally perform poorly as lie detectors, recognizing lies at levels barely above chance. Not surprisingly then, those whose job it is to detect deception fare no better than the general public in detecting lies. In research, police officers, judges, and even polygraph examiners successfully detected lies at nearly the same levels as untrained college students (Ekman & O'Sullivan, 1991). Research also found that there was little correlation between age, job title or experience in the ability to recognize deceptive individuals. College students recognized lies 52% of the time while polygraphers, judges and police officers recognized it 55-56% of the time. Given that members of these groups generally pride themselves in their ability to detect lies, yet cannot detect deception at rates any greater than the average 20 year-old student, underscores the misunderstanding among law enforcement agencies regarding the detection of deceit.

Assumptions

Nearly 100 years ago, researcher Vittorio Benussi found a link between the act of lying and unconscious and uncontrollable physiological responses. Benussi developed a ratio of inspiration to expiration during interrogation that could be utilized to determine if the subject was being truthful (Grubin & Madsen, 2005). This "Benussi Ratio" provided a strong basis for further development and refinement of methods to detect hidden deception. Much of the early scientific investigation into the field produced similar assumptions that an individual who is concealing information or lying will have an unconscious and uncontrollable physiological response to questioning. Theoretically these responses should be greater when being questioned regarding concealed information or when actively lying, than when they are asked neutral questions (Mastroberardino & Santangelo, 2009). These early practitioners searched for physiological responses that could be related to the body's "nervous" response to lying and developed methods of recording and interpreting these responses. This "nervousness" that researchers were attempting to find and measure is what researchers now term the physiological fight or flight response that can be recorded and interpreted by the examiner (Grubin & Madsen, 2005). This response is an unconscious and uncontrollable response by the body to a threatening stimulus. When the body is presented with a threat, a complex interplay of hormones and neurotransmitters prepares the body to deal with the threat in a way that is amenable to both recording and analyzing (Matte, 1996).

Delimitations of the Study

The National Research Council [NRC] (2003) reviewed several studies of the polygraph's validity and reliability across the differing formats of the polygraph and found that data on one format does not always translate accurately in assessments of other formats. The

quality of many of the studies were so low that they did not meet the threshold that would allow for funding through the NRC. Finally, there is the question as to how much research has been conducted by the federal government that remains classified and as such is not included in the body of literature that is available for study (NRC, 2003).

Methodology

Information for this work was gathered through an analysis of secondary sources to better understand various theories behind the polygraph and their shortcomings, as well as the various alternatives. Data came from federal and state laws and rules of evidence, psychology, psychiatry, forensic sciences and medicine.

II. LITERATURE REVIEW

Nature of Deception

Lying refers to the deliberate communication of false information to another with the intent to deceive (Grubin, 2005). This deception is a major aspect of social interaction used in approximately 27% of face-to-face interactions (Hancock, 2007) and on average two times a day (Porter & ten Brinke, 2010). DePaulo, Lindsay, Malone, Muhlenbruck, Charlton and Cooper (2003) defined deception as the deliberate attempt of an individual to mislead others where the communicator is not mistaken or self-deceived. Grubin (2005) pointed out that lying spans a large spectrum from simple lies used to smooth everyday social interactions to others that are designed to provide some gain to the teller, such as avoiding punishment or to manipulate others' perceptions.

Ekman and O'Sullivan (2006) identified two basic types of lies; low-stakes lies and high-stakes lies. Low-stakes lies are those where the threat of exposure offers nothing more than embarrassment for the parties involved. Conversely, high-stakes lie are those where the

consequences of the success or failure for the liar can have important consequences for all parties involved, such as in criminal investigations, pre-employment investigations, and tests for espionage. Telling high-stakes lies is a complex and psychologically stressful task for most individuals (Porter & ten Brinke, 2010). The liar must keep the details of the lie straight while attempting to mask powerful emotions such as fear, anger, excitement or remorse, and exhibiting the proper emotions for the setting (Porter & ten Brinke, 2010). This complex interaction of human emotion affects human physiology in ways that researchers have attempted to definitively link together in a way that lying and deception can be uncovered (Granhag & Strömwall, 2004).

The Equipment of Detection

The polygraph is the most widely utilized and studied means of detecting lies and deception in use today (Happel, 2005). Although widespread in its use in federal, state, and local government settings, there is little agreement on the accuracy of polygraph testing (Honts & Amato, 2007). The terms polygraph and lie detector have become nearly synonymous in their use, however in technical terms the polygraph refers only to the instrument that is used in the test (Meijer & Verschuere, 2010). The polygraph machine itself is a relatively simple machine that usually measures and collects four "channels" of information collected of the examinee's physiological output. These four channels are: the pneumograph measuring respiration, the cardiograph measuring pulse rate and strength, the sphygmograph measuring blood pressure, and the galvanometer which measures the conductivity of the skin (Matte, 1996). Some exams also employ methods for monitoring the examinee's movement during the examination that may be part of an attempt to manipulate the test using countermeasures (Elaad & Ben-Shakhar, 2009).

The polygraph examination consists of a series of yes or no questions that the examinee answers while connected to the machine (NRC, 2003). The original analog polygraph machines

recorded this information on a continuously moving sheet of paper leaving traces in ink to be read and interpreted by the examiner. Modern digital polygraphs run through computers and keep a digital record rather than a paper record (Honts & Amato, 2007).

Assumptions

Two assumptions underlie the foundation of polygraph testing (Harris, 2008). The first assumption is that there is a direct relationship between deception/lying and an individual's emotional state (Ben-Shakhar, Bar-Hillel & Kremnitzer, 2002). The second assumption is that there is a direct relationship between an individual's emotional state and the unconscious physiological responses of the body (NRC, 2003). By utilizing this causal chain, polygraph advocates claim that the measurement of physiological change can be used as a proxy for emotional change. These physiological changes will show differing amplitudes of change in truthful individuals versus deceptive individuals who fear detection which alters physiological outputs (Harris, 2008). An assumption is also made that factors unrelated to deception, such as fear or nervousness, do not affect this change and would cause an improper conclusion to be drawn from the results of the exam (Faigman, Fienberg & Stern, 2003). These two assumptions are the basis for much of the controversy surrounding polygraph testing (NRC, 2003).

Physiology

The human body is equipped with a nervous system that reflexively and unconsciously prepares the body to respond to threats (Matte, 1996). Termed the autonomic nervous system, this complex system controls the involuntary reflexes of the body including heart rate, pulse, blood pressure, breathing and sweating (Woodrow, 2011). When a threat is detected, the autonomic nervous system activates the sympathetic nervous system in preparation for the threat. The sympathetic nervous system is then activated in response and works to balance the actions of

the parasympathetic system to bring the body's functions back into homeostasis – the baseline state of the body (Matte, 1996).

The activation of the sympathetic system in preparation to face a threat is termed the fight or flight response (Kuykendall, 2005). The body begins to move blood towards its core, the heart pumps faster and harder increasing both blood pressure and pulse rate, and forces shallower breathing by the tensing of muscles in the body (Matte, 1996). The sympathetic nervous system also releases compounds that cause the body to release sweat and the pupils to dilate (Woodrow, 2011).

The parasympathetic system works to counteract the actions of the sympathetic system to bring the body back to its normal state. The parasympathetic system lowers the heart rate and dilates arteries and capillaries allowing for a drop in blood pressure and for blood to flow back into extremities (Woodrow, 2011). Under stress the sympathetic nervous system's activities exert the majority of the control over the body's physiological responses, while the parasympathetic becomes more active when the threat is perceived to have passed (Matte, 1996). Four observations of change in physiology are currently used in the assessment of polygraph examinees. Each of these responses is of interest to the polygraph examiner as their measurement and observation of change underlie the theories associated with the detection of deception. Matte (1996) reported that the actions of the sympathetic and parasympathetic nervous systems produces easily observed and quantifiable effects that can be used to gauge an examinee's emotional state during the polygraph process.

Respiration rate and volume.

Prior to the presentation of a threatening stimulus the examinee's breathing should be regular in its timing, and the volume of inhalation and exhalation should remain stable.

Threatening questions stimulate the fight or flight response and the examinee's breathing should be altered to an easily observable degree (Matte, 1996). Gamer (2011) stated that respiratory activity changes in response to a threat by a reduction in amplitude of inspiration, the volume of air taken into the lungs, and a reduction in respiration rate, which should then gradually return to normal as the threat has passed.

Blood pressure.

Prior to being presented with threatening questions the examinee's blood pressure should remain roughly the same but may trend higher or lower during testing (Woodrow, 2011). When exposed to a threatening question the deceptive examinee will be expected to show a change in blood pressure either increasing or decreasing. Any transitory change in pressure with a return to the baseline level is indicative of a stress reaction (Matte, 1996).

Pulse rate and strength.

Closely associated with changes in blood pressure are changes in pulse rate and strength. Prior to being presented with threatening stimuli, the examinee's pulse should show a constant rate or may trend higher or lower (Matte, 1996). When presented with a threat the examinee's pulse should change in rate and strength for a short period of time and then return to its baseline levels as the body returns to its normal state (Woodrow, 2011). Matte (1996) stated pulse rate and strength can either increase or decrease but the indicator of perceived threat is the presence of change over a short period before the return to the baseline pulse rate and strength. Gamer (2011) differed from Matte in stating that pulse rate and strength decrease when the examinee is exposed to threatening questions as the constriction of capillaries and a decrease in heart rate causes an observed drop in pulse. Hira and Furumitsu (2009) found that there were differences between deceptive and non-deceptive examinees in both baseline pulse rate and pulse rate

deceleration due to habituation during testing. The authors found that deceptive examinees had higher baseline pulse rates and lower changes in rate than non-deceptive examinees due to the deceptive examinee's fear of discovery that persisted throughout the testing process.

Skin conductivity (galvanic skin response).

David Lykken in the late 1950's showed that there was a measurably larger change in skin conductance in individuals who were questioned regarding concealed information versus control/comparison questions (Gamer, 2011). As the examinee is presented with the threatening stimulus, the body produces a larger amount of sweat which increases the conductivity of the skin. Gamer found that the rate of change in skin conductance is also related to the intensity of the perceived threat. The greater the perceived threat, the larger the response of the nervous system, which releases more sweat which increases skin conductance to a greater degree.

Test Procedure

Generally the polygraph procedure consists of three distinct phases. The first step is a pre-test interview where the examinee may fill out a questionnaire and is briefed on the technique of the polygraph. For some formats of the polygraph the actual test questions are reviewed (Polygraph Law Enforcement Accreditation [PLEA], 2010). As part of this pretest, the examiner seeks to induce an examinee's concern about being caught lying during the exam (American Psychological Association [APA], 2004). The Office of Technology Assessment [OTA] (1983) found that the pretest interview is necessary to generate the proper psychological climate necessary for valid testing. This process serves to ease the concerns of non-deceptive examinees and to generate anxiety in deceptive examinees. Examinees may be questioned regarding health status, drug use, and intent to deceive the test. Often the examiner will perform a small demonstration called a "stim test" where the examinee is asked to purposely lie to the

examiner in order to show that the machine is capable of detecting even the smallest lie (Osugi, 2011). This procedure is designed to further induce concern in the examinee that the testing process will be extremely sensitive to deception (Meijer & Verschuere, 2010). An example formulated by Leonarde Keeler, the inventor of the Keeler Polygraph, is the card test. In the card test, the examinee chooses a card from a set and the examiner instructs the individual to lie about the number on the card when questioned. A greater physiological response should be observed when the examinee lies about the number they had chosen versus the other numbers in the set, further reinforcing the examinee's belief in the abilities of the testing procedure (Woodrow, 2011).

After the pre-test portion the testing portion begins. This includes a short period without questioning where the examiner collects data on the examinee's baseline physiology (blood pressure, heart rate, respiration rate, and skin conductivity). The examinee is then given a series of yes or no questions relevant to the type of investigation at hand with a short period of time between questions for monitoring physiological responses (OTA, 1983). This series of questions may then be repeated to obtain a second or third reading for each question (Department of Defense [DoD], 2004).

In the post-test portion of the exam the examiner will discuss the results of the test and may question the examinee further if the examiner believes that deception is indicated on any of the questions (Honts, 2004). Some anti-polygraph literature states that the examiner may lie to the examinee in the post-test phase about deception being indicated on certain questions in an attempt to elicit admissions by the examinee (Maschke & Scalabrini, 2005).

Evaluation of the Results

Examination and interpretation of test results is accomplished by comparing the physiological responses of relevant questions that are directly related to the investigation to those responses to control questions that are not directly related to the investigation (Honts, 2004). Deception is measured by the differential responses between relevant questions and control questions (Ben-Shakhar, 2008). The physiological responses should be minimal between relevant and control questions in the non-deceptive examinee, where the deceptive examinee should have well-defined and measurable differences between the control and relevant questions (Honts, 2004). This differential should be produced by the fight or flight response induced by the threat of the relevant question to the deceptive examinee (Ben-Shakhar, 2008).

Responses to the relevant and comparison questions are only compared for the individual being tested as physiological responses to stress vary in each individual and can even be altered by other stimuli present during the examination such as sudden noises or movement (Kosslyn, Cacioppo, Davidson, Hugdahl, Lovallo, Spiegel and Rose, 2002). This variability of an individual's response requires that any changes in response be compared only to those responses taken within that test and cannot be compared over different test sessions (NRC, 2003). Gamer (2011) noted that changes in physiological response cannot be considered indicative of deception alone and must be compared to any changes that occur during comparison questions within that same test session.

Test Formats

Control Question Test.

The most widely utilized format of polygraph testing is the Control Question Test or CQT (Meijer & Verschuere, 2010). In the CQT test process, the examinee first completes an interview process where the testing procedure is explained and an attempt is made to convince

the examinee that the machine will be able to detect any deception on the part of the examinee (Meijer & Verschuere, 2010). The examinee then answers a series of questions while being monitored by the polygraph apparatus. Mixed within this set of questions are relevant and control questions. Control questions are non-specific in their wording but are designed to elicit some anxiety in the examinee and may refer non-specifically to similar criminal activity related to the investigation at hand (Meijer & Verschuere, 2010). Relevant questions deal specifically with the investigation at hand (Happel, 2005). The series of questions is usually repeated two more times with a short break in between each series with the questions repeated in a different order. Deception in the CQT is inferred by the differential pattern of physiological responses to the control and relevant questions (Iacono, 2011).

CQT theory operates on the assumption that the questions most threatening to the examinee will induce larger physiological responses than those which are perceived as less threatening. (Verschuere & Crombez, 2008). In the CQT the assumption is made that the deceptive examinees will have the greatest physiological response to relevant questions where truthful examinees will have the greater physiological responses to control questions (Meijer & Verschuere, 2010). Iacono (2011) elaborated on this by stating that the innocent/non-deceptive examinee has a greater physiological response to control questions as they fear the more open-ended questions regarding past behaviors, while the deceptive/guilty examinee is more threatened by the specific nature of the relevant questions.

Relevant/Irrelevant Test.

The Relevant/Irrelevant Test, or RIT, is a test similar to the CQT where the irrelevant control questions are not designed to elicit any emotional response from the examinee. These questions are typically innocuous in nature such as the day of the week, what city the examinee

is in or the color of the wall (NRC, 2003). The examiner will look at the magnitude of the differences between the questions relevant to the examination versus those that are irrelevant. Following the fight or flight theory, the deceptive examinee will show a differential physiological response between relevant and irrelevant questions where the innocent examinee should have similar responses across all questions (Bull, Baron, Gudjonsson, Hampson, Rippon and Vrij, 2004).

Guilty Knowledge Test/Concealed Information Test.

The Guilty Knowledge Test, or GKT, alternately known as the Concealed Information Test, or, CIT, is designed to determine whether the examinee possesses knowledge of a crime that they would only know if they were involved in the crime (Elaad, & Ben-Shakhar, 2009). Verschuere and Crombez (2008) state that the GKT/CIT test, like the other forms of polygraphy, is based on the body's response to a sudden and significant stimulus.

The GKT/CIT test format consists of a set of multiple choice questions were one item is a true fact related the crime in question and is interspersed with several possible alternatives that are plausible but incorrect (Ben-Shakhar & Elaad, 2003). As each question in the series is asked, the examinee's physiological responses are monitored. GKT/CIT theory postulates that innocent examinees will produce greater physiological responses at rates no greater than chance to the relevant item. Conversely, the guilty examinee should have the highest response to the relevant choices throughout the series of questions (Iacono, 2011). Happel (2005) believed that the GKT/CIT differs from the CQT in that the GKT/CIT is not a test of deception but instead is a test of recognition.

Controversy

While there exists little argument that the polygraph accurately measures the physiological responses of the examinee, there is little agreement between the scientific community and the practitioners of polygraphy as to the correlation between changes in these indicators and deception (NRC, 2003). According to the APA (2004), practitioners of the polygraph believe that the measurements collected by the polygraph do not directly detect deception. Instead, deception is inferred by the belief that the measured changes in physiological response is greater when being deceptive than when being truthful. Others believe that the polygraph is a symbolic instrument and part of a ritualized spectacle (Bunn, 2007), and that the ability of the polygraph to gain information is due more to intimidation than the validity of the concept (Meijer & Verschuere, 2010). The APA (2004) found that research into polygraphy has not separated the placebo effect of the examinee's belief in the accuracy of the machine from any actual link between deception and physiological responses. Polygraph testing may appear to be accurate as examinees who feel the test will detect their guilt may confess their guilt or be anxious during the questioning portion of the test procedure. Bull et al. (2004) found that innocent examinees tend to show higher levels of psychophysiological arousal during testing and as such, polygraph interrogation is ineffective. Meijer, Verschuere, Merckelbach and Crombez (2008) found that it is impossible to assess the origins of physiological responses, and the truthful examinee may present strong responses to questioning out of fear or association with stressful memories rather than guilt.

Accuracy and Validity

The NRC (2003) maintained that research in the field of polygraphy has not progressed in the proper manner of scientific study. The NRC also found that one of the biggest problems surrounding accurate research is the lack of an ability to establish a baseline truth rate among

examinees. The NRC found that many studies used confession among examinees whose results showed deception as a metric for judging the accuracy of the technique. The polygraph has largely been developed outside of academia and is administered, interpreted, and championed by those without the proper qualifications to comprehend the test. This lack of background causes practitioners to rely almost exclusively on what they are taught in training which is provided by those with a vested interest in polygraphy, namely the faculty of the schools and the industry supplying the hardware. Pollina, Dollins, Senter, Krapohl and Ryan (2004) and Carmel, Dayan, Naveh, Raveh and Ben-Shakhar (2003) found that accuracy rates in laboratory testing of the polygraph suffer greatly from a lack of validity. Both sets of authors found laboratory settings cannot reproduce the stress and psychological state of examinees in real world settings and that field tests have no way of determining the number of deceptive examinees who escape detection.

The Relevant/Irrelevant test and the CQT have been criticized by the scientific community for many perceived shortcomings but the most controversial are the basic assumptions underlying the test (Meijer & Verschuere, 2010). Opponents of CQT and RIT testing maintain that these tests rely on a stress-inducing effect that has not been proven to be exclusively related to fear of detection. Opponents claimed this stress is instead related to the examiner's explanation of the test's supposed accuracy given prior to the test (Meijer & Verschuere, 2010). Cullen & Bradley (2004) believe that control questions in the CQT and the testing process itself can evoke strong psychophysiological responses in innocent examinees who feel they are subject to interrogation for a crime they did not commit. Meijer, Verschuere, Smulders, Johnston and Merckelbach (2007) criticized the CQT for its lack of theoretical framework, standardization, and controls which result in an unacceptable high rate of false positives. There has been little study of the psychophysiological relationships relied upon in

CQT/RIT testing to differentiate the deceptive from the innocent. Iacono (2000) found that the RIT technique had a greater than 70% error rate regarding innocent examinees whereas Meijer and Verschuere (2010) compiled data on 44 studies and found that accuracy in the CQT tests ranged from 74-89% for guilty examinees with up to a 13% false negative rate. Innocent examinees were identified between 59-83% of the time and the rate of false positives reached 23%.

Many sources of possible interference have also been noted by researchers. Cullen and Bradley (2004) found that the results of the CQT test could be influenced by the positioning of relevant and control test questions within each test series. Pollina et al. (2004) found that there were a number of sources of variability that affected test outcome including the format of the test, the personalities of the examiner and examinee, and the scoring rules used to render an opinion of the test results. Honts, Amato and Gordon (2004) found that outside issues can reduce the accuracy of the CQT test when the examinee is more focused on something else and thus does not respond appropriately to questioning producing a false negative result.

The GKT/CIT format has received less criticism from the scientific community as more scientific studies of higher quality have been conducted on the GKT/CIT (Meijer et al., 2007). Elaad (2003) found the GKT/CIT test had an accuracy rate for guilty examinees reaching 81%, while the test was able to identify innocent examinees at a rate of 96%. Ben-Shakhar and Elaad (2003) found that GKT/CIT testing provided a greater safeguard against false positives and the validity could be determined mathematically prior to testing. The probability corresponded with the number of test questions provided and rises as a multiple of the number of questions asked (Bradley & Barefoot, 2010). For example, a test with four questions, each with four answers per

question, gives a 0.004 percent chance of the innocent examinee having the strongest physiological response to all four relevant items.

Problem Areas in Testing

Many problems exist in the area of intentional manipulation and unintentional altering of polygraph results and issues surrounding the suitability of some individuals for testing. These issues can range from deliberate attempts by the examinee to alter their physiological state during testing (Maschke & Scalabrini, 2005), to legitimate prescription drug use (Kuykendall, 2005), to mental health issues of the examinee (Verschuere, Crombez, De Clercq and Koster, 2005). Each of these issues presented a serious threat to the accuracy of the testing process and examiners must be able to identify these problem areas and have knowledge of how they can affect test outcomes (Honts, 2004).

Countermeasures.

Honts (2004) divided countermeasures into four category types: Informational Countermeasures, Spontaneous Countermeasures, General State Countermeasures, and Specific Point Countermeasures. Informational Countermeasures are those that exist due do the examinee's familiarity with testing procedures which may reduce the intimidation or fear that the testing process is designed to induce. Spontaneous Countermeasures are those utilized by the examinee in an attempt to alter the outcome of the test without having an understanding of how countermeasures will affect their physiological responses. General State Countermeasures are actions which affect the examinee throughout the entirety of the test. Examples include ingestion of high blood pressure medications, tranquilizers, antihistamines, and anti-depressants in an effort to alter physiological response to questioning (Matte, 1996). Specific Point Countermeasures are those where the examinee engages in a physical countermeasure such as

self-induced pain or a mental countermeasure, such as envisioning a physical threat during control questions that may reduce the differences between relevant and control question output (Ben-Shakhar, 2011).

Mental Health Issues.

Mental health issues may also affect the reliability of the test. Verschuere et al. (2005) examined the role that psychopathic traits have on the accuracy/validity of polygraph testing. The authors found that psychopathic and under-socialized individuals showed a measureable decrease in skin conductivity during polygraph testing. This severely undermined the validity of polygraph testing and greatly increases the chances of anti-social individuals escaping detection.

Matte (1996) presented an entire chapter dedicated to the effects that different psychological problems may present in polygraphy such as anxiety disorders, mood disorders, psychotic disorders and dissociative disorders. Anxiety disorders such as panic disorder, agoraphobia, obsessive-compulsive behaviors, post-traumatic stress disorder and generalized anxiety disorder can interfere with the testing process and may even exacerbate an examinee's symptoms. In each of these disorders, polygraph testing may reveal significantly elevated arousal that is unrelated to deception-induced stress during testing, which may cause difficulties in interpreting the test results.

Mood disorders may cause difficulties for the examiner dependent on the type of disorder and which symptoms are being displayed. Individuals in a depressive state may produce unresponsive chart readings, where individuals in a manic state will likely produce erratic results, both of which produce test results which are of no value for the polygrapher.

Psychotic disorders deal with alterations of consciousness and perception, and as such, individuals suffering from disorders such as Schizophrenia, Delusional Disorder, and

Dissociative Disorders present issues which may prevent proper testing. Schizophrenics typically have decreased physiological responses and may also exhibit a lack of homeostasis, where physiological output is constantly changing without outside stimulus. Individuals with Delusional Disorders can be effectively polygraphed if questioning does not involve any issues related to the delusional theme. Questions related to the delusional theme may cause the individual to respond in a manner which confirms their delusion and thus is felt to be true even though in reality it is false. Under the theory of polygraphy this individual will not present physiological changes associated with deception as they are not self-aware of the deception.

Matte's final discussion centers on Dissociative Disorders. Depersonalization affects the individual's self-perception and causes them to feel that their connection to reality is lost or altered and may affect physiological responses to questions regarding previous actions. Dissociative Amnesia and Dissociative Fugue will prevent polygraph testing for events and time periods during which the individual suffers the amnesia or during the fugue state. Dissociative Identity Disorder or Multiple Personality Disorder produces a unique problem where each personality has its own sets of memories and personality traits and the actions of each personality. In some cases, the actions of personalities may be known by others and in some cases they may be completely separate. In these cases the likelihood of producing a valid test are low. These disorders are typically of concern only in polygraphs related to criminal investigations as individuals with such issues would not likely be subject to a pre-employment polygraph for law enforcement positions.

Stigma & Expectancies.

Stigmas and expectancies may also play a significant role in the accuracy of polygraph results. The NRC (2003) found that stigmatized groups, especially racially stigmatized groups,

may be more likely to exhibit a threat response in situations such as polygraph testing. Blascovich (2001) found that increased physiological arousal, especially galvanic skin response, occurs in some individuals in stigmatized groups during test taking and interpersonal interactions. Doll, Law and Piotrowski (1990) state that examinees are less physiologically aroused by examiners of the same background and conversely physiological arousal is increased if examiner and examinee are of different ethnic backgrounds.

The expectancies of the examiner, the belief that the examinee is guilty or innocent, can also affect the results of the polygraph test. The NRC (2003) stated expectancies can affect the validity of testing as the examiner's beliefs about the test taker's guilt or innocence may affect testing in multiple ways. The authors state that an examiner's demeanor could induce a physiological stress reaction in an examinee, examiner's beliefs could influence test question formulation, and it may affect how the examiner scores the results of the polygraph test.

Alternative Methods of Detection

Concerns about the validity of current polygraph methods have led to research into alternative methods for detecting lies and deception. Some of these methods include analyzing changes in vocal patterns, analysis of facial expressions, and imaging of areas in the brain during questioning. These alternative techniques are similar in theory to polygraph testing in that there is an assumption that the body reacts differently when lying, however these tests involve monitoring the examinee in novel ways (Bell & Grubin, 2010).

Voice Stress Analysis/Computerized Voice Stress Analysis.

Computerized Voice Stress Analysis, CVSA or VSA, uses computer analysis to detect deception by analyzing the qualities of the examinee's voice during questioning (Bhatt & Brandon, 2008). Harnsberger, Hollien, Martin and Martin (2009) stated that VSA measures the

micro-tremors in laryngeal (voice box) muscles to evaluate psychological and physiological stress in deceptive speech. In their review of VSA for the United States Air Force, Hopkins, Benincasa, Ratley and Greico (2005) stated that the muscles of the human body vibrate in the eight to twelve Hertz range and this frequency changes when the body reacts in a fight or flight response when attempting to conceal deception. Similar to the polygraph, VSA technology compares frequency patterns produced during relevant questions to those produced during control questions (Damphousse, Pointon, Upchurch and Moore, 2007). In their review of VSA technology Hopkins et al. (2005) stated that VSA technologies could detect deception at rates above chance but the accuracy of the testing was dependent on the experience of the examiner. Included in their summary was the statement that VSA, like polygraph testing, is more likely to convince an examinee to confess through fear of the testing process than it is to detect the examinee's deception. Harnsberger et al. (2009) came to a similar conclusion that the success of VSA testing is more likely due to the skills of the interrogator in eliciting confessions from examinees.

Neuro-imaging.

Investigations are ongoing into non-invasive magnetic imaging of the brain using functional Magnetic Resonance Imaging, fMRI, to study what areas of the brain are activated during deception and how to utilize this knowledge to develop a test for deception (Kozel, Johnson, Mu, Grenesko, Laken and George, 2005). Ganis, Kosslyn, Stose, Thompson and Yurgelun-Todd (2003) and Nuñez, Casey, Egner, Hare and Hirsch (2005) found that different areas of the brain were active when individuals were asked to lie about personal information than were active when the brain was not being tasked with formulating a lie. Kozel et al. (2005) conducted a study that found that examinees attempting to deceive the interrogator activated

certain areas of the brain associated with decision-making that were not active when not being deceptive. The authors found that their testing was 90% accurate in detecting deception. The authors also found that countermeasures known to affect the traditional polygraph did not reduce the likelihood of detection.

Facial Expressions.

The evaluation of facial expressions is another area of study that shows promise in the detection of deception. Researchers are looking at what are called micro-facial expressions which researchers believe may be a suppressed display of the individual's true emotion (Ekman & O'Sullivan, 2006). Micro-facial expressions are the brief, involuntary expression of an experienced emotion that lasts between 1/25th and one second (Ventrelli & Simon, 2012). Persaud (2005) stated that microexpressions are the "leaking" of strong emotions, such as anger and guilt, that occur even when the individual attempts to suppress the emotion. Micro-facial expression may be able to be used as an adjunct to other forms of deception detection by utilizing the Facial Action Coding System or FACS. FACS uses computerized image analysis of the human face to identify leaked emotions in the facial features of examinees (Bartlett, Hager, Ekman and Sejnowski, 1999). The utility of this process may be limited as currently microexpressions can only be shown to tell what emotion the individual is feeling, not why they are feeling it (Ventrelli & Simon, 2012).

Legal Aspects

Where polygraph testing and other tests for deception may be utilized in personnel screening and in the course of criminal investigations, its use in a courtroom setting is more limited and varies between jurisdictions. Some jurisdictions have per se prohibitions on the introduction of polygraph evidence and some admit evidence only when both sides stipulate to

its introduction (Harris, 2008). In every jurisdiction the admissibility of polygraph evidence is controlled either by legislative action or by judicial precedent.

One of the earliest attempts to admit polygraph evidence into court, and one of the earliest judicial decisions on the admissibility of scientific evidence was *Frye v. United States* (1923). In *Frye*, one of the early pioneers in the field of polygraphy, William Marston, attempted to have the results of an early version of the polygraph test admitted into court (Peters, 2000). The Court of Appeals for the District of Columbia ruled that in order for scientific evidence to be admissible in a court of law, the evidence in question must be the result of a scientific theory of general acceptance (Harris, 2008). The court felt that the rudimentary lie detection technique at question in this case had not gained widespread acceptance in the scientific community and thus could bias the jury in its fact finding role (McCabe, Castel & Rhodes, 2011). The *Frye* decision, which became known as the general acceptance test, set the standard for the admissibility of scientific evidence for federal courts as well as many state courts for 70 years, and affected the use of the polygraph in courtroom settings (Keierleber & Bohan, 2005). Courts generally rejected polygraph testing under the *Frye* doctrine through two general arguments; that the theory behind polygraph testing is sound but the technique is flawed, or by rejecting the theory underlying polygraphy as unsubstantiated and that experimentation has failed to establish the accuracy and reliability of the test (Harris, 2008).

Frye was overturned at the federal level by *Daubert v. Merrell Dow Pharmaceuticals, Inc.* (1993) as inconsistent with the Federal Rules of Evidence (FRE). The Federal Rules of Evidence state that evidence seeking admission must qualify as "scientific knowledge" and inferences must be derived by the scientific method and be supported by validation (Peters, 2000). The *Daubert* decision, utilizing the Federal Rules of Evidence, articulates four specific

factors that are used for determining the admissibility of scientific evidence; (1) whether the theory or technique has or can be tested, (2) the methods in question have been peer reviewed and published, (3) the error rate of the technique is known, and (4) the technique or methodology is generally accepted in the relevant scientific community (Kesan, 1997).

Daubert and the Federal Rules of Evidence affect the admission of polygraph evidence in that the judge is required to act as the gatekeeper in reviewing scientific evidence using these four criteria. Judges are required to form an opinion on the validity and reliability of the testing process (Saxe & Ben-Shakhar, 1999). Gallai (1999) pointed out that polygraph testing is deficient in two of the four criteria that need to be met to be accepted under *Daubert*. The author found that polygraph testing fails *Daubert's* testing criteria in that it is difficult, if not impossible, to test the underlying theories adequately and the ease of manipulation via countermeasures inhibits accuracy testing. Gallai (1999) also pointed out that studies of polygraphy have shown a wide range of error rates and that there exists no universally accepted standards by which polygraph examinations can be judged, both of which are fatal under *Daubert*. Gallai found that polygraph testing is not generally accepted within the relevant scientific communities and that opinions on the polygraph are generally polarized. Gallai does not argue the fact that polygraph testing meets the peer review and publishing standard but points out that publishing and peer review do not always correlate with reliability.

Some states have adopted *Daubert* or *Daubert*-type rules for admissibility, whereas some states utilize *Frye*-type standards, and others have adopted their own rules for admissibility (Harris, 2008). Kaufman (2006) analyzed state rules of evidence precedent and found that 30 states use *Daubert* or standards consistent with *Daubert*, 14 states and the District of Columbia reject *Daubert* and retain *Frye*, and seven states have unique standards for admitting scientific

evidence. This variability between court jurisdictions is illustrated by the statistics surrounding admissibility. Grubin & Madsen (2005) found that polygraph evidence may be admissible in some circumstances in 19 states and nine of the twelve federal circuits. Harris (2008) pointed out that the admissibility of polygraph evidence in court is constantly changing as indicated by some courts changing stance multiple times on polygraph admissibility. While the lack of admissibility in courts may affect the use of polygraph to some extent, polygraph use will likely continue in non-judicial settings where the polygraph provides its utility prior to entering the courtroom by eliciting confessions (Harris, 2008).

III. THEORY & RECOMMENDATIONS

Theory

In order for polygraph testing to meet the standards required for scientific validity, well-supported theories must be tested to ensure that polygraph methods are valid and they have the ability to detect physiological changes associated uniquely with deception. Verschuere and Ben-Shakhar (2011) break down the proposed theories underlying the polygraph into emotional-motivational theories and cognitive theories. Emotional-motivational approaches encompass the conditioned response, punishment/defensive reflex, emotional conflict, and motivational impairment theories. Cognitive approaches comprise the closely related orienting response (OR) and dichotomization theories. In all of these theories, the fight or flight activation of the autonomic nervous system is considered to be the trigger for the physiological changes used to determine if deception is present.

Conditioned response theory can be described in terms of Pavlovian classical conditioning where the process of lying is stressful for the individual who has been taught that lying is wrong (Bell & Grubin, 2011). The examinee's past punishments for lying will invoke a

fear of being caught in a lie, causing the autonomic nervous system to be stimulated to an observable degree. Punishment/defensive reflex theory is similar to the conditioned response theory but considers arousal to be caused by the fear of future consequences rather than a conditioned response (Verschuere & Ben-Shakhar, 2011).

Motivational Impairment is similar to Punishment/Defensive Reflex Theory in that the examinee is focused on the possibility of failing the polygraph test (Verschuere & Ben-Shakhar, 2011). This impairment is described as being related to the increased emotions present in individuals who are highly motivated to deceive (Woodward, Hancock & Goorha, 2005). This motivation causes an overcompensation of emotions in an attempt to mask self-perceived nervous behavior. DePaulo et al. (2003) and Woodworth, Hancock and Goorha (2005) found that the more motivated the examinee was to lie, the larger the observed physiological response was due to increasing emotional load. Conflict theory makes the assumption that an overt act of deception produces two contradictory emotional reactions that will produce a physiological response in the examinee (NRC, 2003). These contradictory reactions arise when the basic life-long practiced tendency to answer questions truthfully comes into conflict with the sudden motivation to lie.

Where the above theories have generally been used in an attempt to understand the physiological responses of the examinee during CQT and RIT testing, the Dichotomization and Orienting Response (OR) theories are used to explain the underlying mechanisms at work in Guilty Knowledge Test/Concealed Information testing (Verschuere, Crombez and Koster, 2004). Orienting Response, like Conditioned Response, is related to Pavlov's studies of classical conditioning where the expected response to a stimulus is altered if a novel or personally significant event occurs (NRC, 2003). OR suggests that during GKT/CIT testing all choices in

the answer-set will be of similar "interest" to the innocent examinee, while the guilty examinee will have an enhanced response to the guilty item within the answer-set (Verschuere et al., 2004). Verschuere and Ben-Shakhar (2011) and Sambeth, Maes, Quiroga, Van Rijn and Coenen (2004) stated that the OR is strongly associated with changes in skin conductance and alteration in heart rate.

Dichotomization theorists proposed that the examinee differentiates questions into two categories, relevant and irrelevant (Verschuere & Ben-Shakhar, 2011). As each set of questions is asked, the innocent examinee habituates, becomes desensitized, similarly to all items within the set (Ben-Shakhar, 1977). The guilty examinee habituates to all irrelevant items in the question-set but the guilty item presents an important stimulus, producing a larger physiological response (NRC, 2003). As with OR theory, the guilty examinee should have significant changes in skin conductance and heart rate when presented with the relevant item (Verschuere & Ben-Shakhar, 2011).

Recommendations

Research and criticism of the accuracy of the polygraph has been somewhat divergent in regards to the two basic types of polygraph testing. The GKT/CIT test format showed higher levels of validity and have showed significantly lower numbers of false positives (Elaad, 2003) and higher quality research (Meijer et al., 2007). With the ability to determine the test's accuracy prior to testing and greater ability to protect against false positives, this format has suffered less criticism due to a closer adherence to the scientific method (Bradley & Barefoot, 2010).

The remaining formats, CQT and RIT, have drawn far larger amounts of criticism from nearly every scientific discipline. The NRC (2003) found that quality researchers rarely conduct

research in the field of polygraphy while Bull et al. (2004) found that the CQT and RIT format is so poorly regarded in the scientific community that few quality researchers are willing to devote their career to their study. It also appears that these test formats have only limited room for improvement and that a century of study has failed to prove that these tests can have high rates of accuracy (NRC, 2003).

While the ability of CQT and RIT testing to elicit confessions may be of utility in specific incident criminal investigations, there remain serious questions regarding its use in pre-employment screening and periodic re-screening of employees. The NRC (2003) found the few quality studies that have been conducted on these formats involved specific incident scenarios and therefore are not applicable to screening of employees. Regardless of this finding, employee screening using CQT/RIT formats continues to be the primary use for the polygraph. The validity of pre-employment screening is also problematic as unsupported inferences are made between past behaviors and future behaviors. There has been no plausible theory developed that links these behaviors and no supporting evidence can be found to support this essential assumption that polygraph practitioners have made (NRC, 2003). Considering the sensitive nature of the institutions where polygraphy is used, law enforcement and national security, there is a misplaced trust in the polygraph's abilities.

In an attempt to address these shortcomings there are methods that may continue to allow the polygraph to be of use. With the known lack of accuracy of CQT and RIT testing, actions regarding employment matters should not be based solely on the results of polygraph outcomes. Instead of being grounds for applicant rejection or employee dismissal, failed polygraph exams should be a trigger for deeper investigation into the individual and their alleged activities (NRC, 2003). The Department of Energy eliminated polygraph screening for new applicants and re-

testing of current employees in response to the NRC findings (Cumming, 2009). In place of this blanket polygraph policy, prospective and current employees are only subject to a polygraph examination if certain predefined criteria are met and no decisions will be made based solely on the examination.

Modifications of current polygraph testing procedure may also benefit the accuracy of the testing process. Honts and Amato (2007) found that the human interpretation of test results is one of the weakest points of the polygraph and that the automation of scoring could improve accuracy. According to the authors, even the most skilled examiner brings bias into the examination which can affect scoring both positively and negatively for an examinee. According to the authors the automation of scoring removes human bias from interpretation and allows for easier training of examiners (Hopkins et al., 2005). Automation also puts the focus on developing better questioning and interrogation techniques which may add to the utility of the testing process (Honts & Amato, 2007).

The final recommendation deals with newer technologies in the field of the detection of deception. Hopkins et al. (2005) state that a fusion of Voice Stress Analysis and traditional polygraphy may lead to enhanced accuracy in the testing for deception. The authors delineate two methods by which both methods may produce greater accuracy, the parallel method and the serial method. The parallel method allows the traditional polygraph and VSA testing to be run at the same time which may enhance the probability of identifying deception according to Hopkins et al. (2005). Serial testing involves the use of VSA during the pre-test portion of the polygraph which may help the examiner to identify areas where the examinee shows stress and can help develop polygraph questions which are directed to these areas (Hopkins et al., 2005). As technologies such as the fMRI mature, they may supplant the traditional polygraph in their

ability to accurately discerne truth from deception and may be less susceptible to countermeasures (Bell & Grubin, 2010).

As has been stated by both proponents and critics of polygraphy, the most important issue at hand is the need for further research into both the fields of traditional polygraphy, as well as possble adjunct or replacement methods of detection. The field of polygraphy has made improvements in methods and theory over the preceding 100 years, but still is reliant on chance and human assumptions to an unacceptable degree given the task that it has been asked to perform. While polygraphy has served a utilitarian purpose over the previous century, new methodologies and technologies promise to enhance the ability to detect deception with ever increasing accuracy.

IV. CONCLUSION

Misconceptions regarding the polygraph and its abilities have been a double-edged sword throughout its history. Those entities utilizing the polygraph have benefited from examinee's anxiety and misconceptions surrounding the polygraph and its abilities to detect deception. Conversely, these same entities have been undermined by their own misconceptions and lack of research into the polygraph's true abilities. Research has consistently shown that the outcome of the polygraph process is greatly influenced by the skill of the examiner and the knowledge and motivation of the examinee.

In screening polygraphs, without skillful question formulation and interrogation by the examiner, confessions are less likely and only the most ardent supporters of the polygraph would be assured that the examinee is being 100% truthful. There is also little to no ability for these agencies to determine the validity of each examinee's test results if no contradictory information is developed through other means of background investigation. Those examinees with a

knowledge of what the polygraph measures and the ability to not be intimidated or manipulated by the examiner have a high likelihood of "beating" the polygraph.

In areas where the screening of applicants and current employees is necessary, the polygraph may continue to serve in its role as a prop for eliciting confessions. However, the polygraph must not be seen as a substitute for in-depth investigation into those seeking jobs in positions of trust or in sensitive government industries. As alternative technologies improve and they are proven to be valid forms of detection, they should supplant the traditional polygraph.

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APPENDIX OF IMAGES

Images of obsolete polygraph machines on display at author's place of employment.

Image 1: Keeler Polygraph Model D

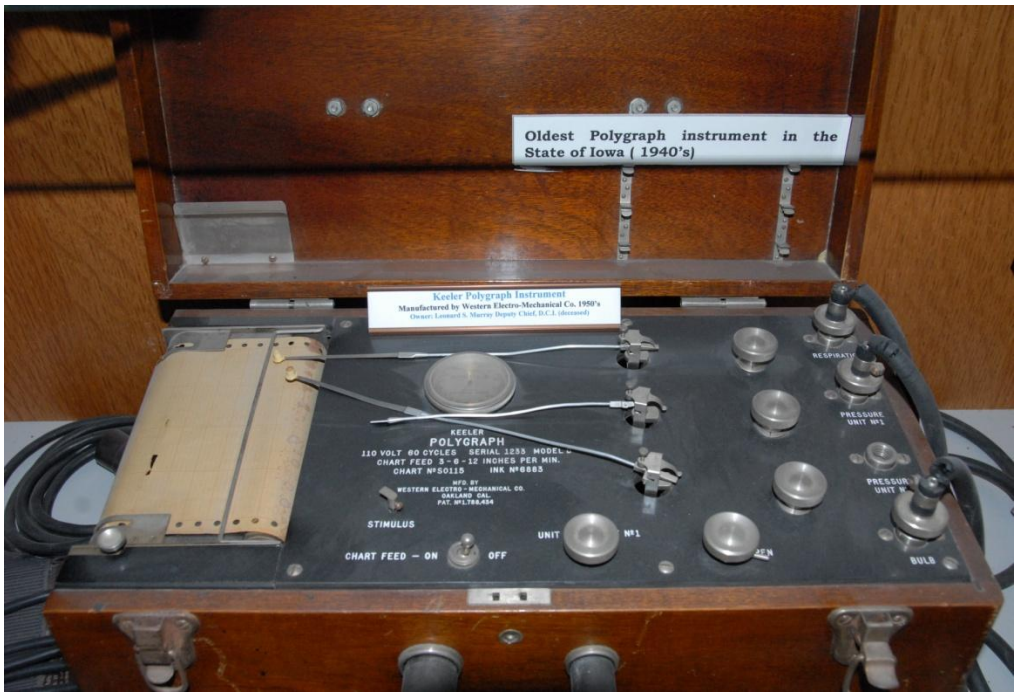

Image 2: Keeler Polygraph Model 6308

Image 3: LaFayette Polygraph, unknown model number