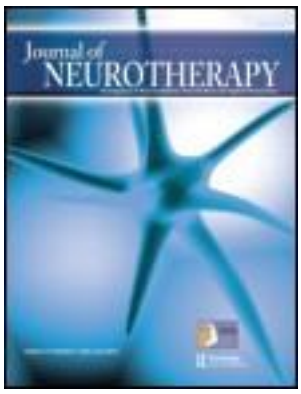

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The qEEG in the Lie Detection Problem: The Localization of Guilt?

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The qEEG in the Lie Detection Problem: The Localization of Guilt?

Kirtley E. Thornton, PhD

SUMMARY. Previous attempts by the author to discern if the qEEG could be an effective instrument in the detection of a lie resulted in positive results (100% effective, 73% of the time; Thornton, 1995). The procedure failed to make a decision in 4 of the 15 events being examined. A new design was created which requires no verbal response of the participant. The participant in the present study was presented with four instructions: (a) allow yourself to be anxious, (b) listen to stories of events of which you have no direct experience or knowledge, (c) listen to stories of self-reported true (real crimes) events which you participated in and feel guilty about your participation, and (d) block the real crime stories (events provided by participant) as they are read to you. The participant's eyes were closed during the entire collection of data and no verbal response was elicited. Analysis of the different cognitive/emotional states with qEEG measures revealed an intriguing predominant pattern of left hemisphere/posterior (dorsal) activation for the experience of anxiety, right hemisphere (right temporal, in particular) activation for the experiencing of guilt and more centrally located activations when the participant attempted to block the real stories.

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KEYWORDS. qEEG, lie detection, guilt, innocence

INTRODUCTION

The history of lie detection by psychophysiological methods has been fraught with problems of human judgment, reliability and validity. Early Hindu medical records (900 B.C.) noted the use of blushing (facial vasodilation) in the detection of guilt (Ben-Shakhar & Furedy, 1990). A most impressive case is attributed to Eristratus, a physician to Alexander the Great, who determined by use of the tumultuous rhythm of the heart that the crown prince of the Seleucid court in Syria was guilty of a sexual relationship with his stepmother. Months later a child was born (Trovillo, 1939, p. 850), confirming for the first time the use of physiological measures in the detection of deception.

William Marston (1917) was the first proponent of lie detection machines. In the Frye versus United States, 54 App. D. C. 46, 47, 293 F. 1013, 1014 case (1923) the rule was established that expert opinion based on a scientific technique is inadmissible unless the technique is "generally accepted" as reliable in the relevant scientific community. Marston's introduction of blood pressure to assess lie detection was accepted by the court as "generally accepted" in this landmark legal case establishing the Frye standard. The polygraph was used and promoted by the Berkeley, California police department in the 1930s. Dozens of polygraph schools sprang up around the country. The industry thrived, with three branches: pre-employment testing, criminal investigation and counterintelligence.

The main methodologies of lie detection are the Control Question Technique (CQT) and the Guilty Knowledge Test (GKT). Descriptions of the following methodologies can be found in the NASA report (Fienberg, 2002) and a publication by Ben-Shakhar and Furedy (1990). The CQT methodology involves construction of a control question which has greater emotional impact than the crime-relevant question (assuming the participant is innocent). Thus the participant may be asked "Did you ever do anything you were ashamed of"? The questions are constructed to be vague and intended to elicit an anxious response. If the reaction to the control question is greater than the relevant question (relevant to the crime), the participant is deemed to be telling the truth. If the reaction to the relevant question is greater than the control question, it is concluded that the participant is lying.

A variant of the CQT methodology (the Directed Lie Test, DLT) asks the participant to lie to a control question (e.g., "Have you ever broken a rule"?) and simultaneously to think about the time they did break a rule. If the participant's reactions to relevant (to the crime) questions are judged by officials to be larger than their reactions to directed-lie questions, the participant is deemed to be lying.

The GKT involves direct questions which are posed to the participant. These questions involve information that only the guilty participant would know. For example, the participant is asked "Was she wearing a black dress that night"? Multiple choice items are generally presented and the participant's response is compared on the "concealed information" (that which the guilty participant would be aware of) to the neutral items. If the participant shows greater physiological response to the "concealed items," guilt is presumed.

The NASA review (Fienberg, 2002) represents the most thorough review of the literature in this area. The report described many different problems in the area.

> For example, in different studies, when a cutoff is used that yields a false positive rate of roughly 10 percent, the sensitivity–the proportion of guilty examinees correctly identified–ranges from 43 to 100 percent. This range is only moderately narrower, roughly 64 to 100 percent, in studies reporting a cutoff that resulted in 30 percent of truthful examinees being judged deceptive. (Fienberg, 2002, p. 105)

> In screening populations with very low base rates of deceptive individuals, even an extremely high percentage of correct classifications can give very unsatisfactory results. This point is illustrated in Table 2-1 (in Chapter 2), which presents an example of a test with an accuracy index of 0.90 that makes 99.5 percent correct classifications in a hypothetical security screening situation, yet lets 8 of 10 spies pass the screen. (Fienberg, 2002, p. 126)

The NASA report concluded:

> Thus, the range of accuracy indexes, from 0.81 to 0.91, that covers the bulk of polygraph research studies, is in our judgment an overestimate of likely accuracy in field application, even when highly trained examiners and reasonably well standardized testing procedures are used. It is impossible, however, to quantify how much of

> an overestimate these numbers represent because of limitations in the data. In our judgment, however, reliance on polygraph testing to perform in practical applications at a level at or above Accuracy Index = 0.90 is not warranted on the basis of either scientific theory or empirical data. Many committee members would place this upper bound considerably lower. (Fienberg, 2002, p. 126)

Popular Lie Detectors

The movement into the popular arena for lie detectors has seen the advent of voice recognition software which presumably will tell if a person is lying. Internet ads for lie detection devices are now common and a device from Israel purports to tell you if your spouse really loves you while he or she talks to you, even providing a rating scale for love. Many of the commercial lie detection devices are, by and large, sensitive to issues of anxiety and tension. Research conducted by the Department of Defense (Cestaro, 1996; Cestaro & Dollins, 1994; Janniro & Cestaro, 1996) has concluded that voice analysis lie detection software does not provide hit rates above chance levels. NASA's report (Fienberg, 2002) underscores the lack of validity of this particular method.

Traditional lie detection methodologies have relied upon autonomic and somatic nervous system response: cardiovascular (i.e., changes in heart rate and blood pressure), electrodermal (i.e., changes in the electrical properties of the skin that vary with the activity of the eccrine sweat gland), and respiratory. Modern electrophysiological measurements (event-related potentials–P300; Rosenfeld, Angell, Johnson, & Qian, 1991) have also been applied to the problem, with similar hit rates to traditional approaches (MacLaren, 2001).

These traditional approaches have several limitations: (a) the time delay between the experiencing of lying and the physiological response, (b) the number of physiological variables being collected, (c) the requirement of a verbal response, and/or (d) the variables can be under the control of the participant. The author designed an approach which employs the qEEG (which does not have the time delay problem), increases the number of available physiological variables, does not require a verbal response and is too difficult for the participant to control (as there are about 3,000 variables being measured). The goal would be a "foolproof" lie detector test which never asks the participant to answer a question.

In this approach, a variance of the GKT technique, a participant is read true stories concerning an event where guilt is reported and stories

of events or crimes about which they have no knowledge. This approach differs from the GKT technique through the collection of qEEG data and the lack of verbal response by the participant. An additional advantage of this design is that story reading involves more time than that required to answer a question, allowing for extensive data collection.

This method also controls for anxiety and blocking, two problems that have plagued traditional methods. The participant provides an anxiety control condition, producing this emotion on his or her own for a minute or two, and a faking or blocking control condition in which a participant is asked to "block" in whatever manner possible the hearing or impact of a story about a real, self-reported, guilt-provoking event in his or her life. Blocking may involve a lack of cognitive processing of verbal information or a suppression of normal emotional responses to a story. How well a participant was able to block a story was not measured for this study.

METHOD

Participant

The participant was a 23-year-old Caucasian female who volunteered for the project. She was not reimbursed for her participation. There was no history of brain injury, neurological disease or other medical history which could affect her qEEG.

Apparatus

The qEEG was acquired using the NRS-24 recording equipment (Lexicor Medical Technology, Inc.) and a 10-20 system Electro-cap with a linked-ears reference. Sampling rate was 256 samples per second, which allows for examination of up to the 64 Hz range with a 60 Hz notch filter. Software filters provided high and low frequency passes at 0.5 and 64 Hz (3dB points), respectively. Signals were subjected to a Fast Fourier Transform (FFT) using cosine-tapered windows which output spectral magnitude in peak-to-peak microvolts as a function of frequency. The bandwidths analyzed were Delta: 0-4 Hz, Theta: 4-8 Hz, Alpha: 8-13 Hz, Beta1: 13-32 Hz, Beta2: 32-64 Hz. Scalp locations were prepped with rubbing alcohol and Nu-Prep and all site impedances were below 5 K ohms, and within 1.5 K of each other. Gain was set to 32,000 and epoch length was set to 1 second. Data were visually ana-

lyzed for artifact and epochs marked for deletion when artifact was evident.

Activation Measures

The following spectral indices were calculated for each recording condition:

1. Average absolute magnitude in microvolts in a band.
2. Average relative magnitude in a band at a site, calculated by dividing absolute magnitude of a particular band by total microvolts in all bands.
3. Peak Amplitude: Peak amplitude in microvolts in a band.
4. Peak Frequency: Peak frequency of a band.

Symmetry: Peak amplitude symmetry between homotopic sites in a band [i.e., defined as $(A - B)/(A + B)$].

Connectivity Measures

Coherence is the average similarity between the waveforms (of a particular band) from two locations over a one-second period of time conceptualized as the strength/number of connections between two locations.

Phase is the time lag between two waveforms from two locations (of a particular band), defined by how soon after the beginning of an epoch a particular waveform from location 1 is matched by that from location 2.

Procedure

The participant was asked to provide five stories concerning her life about which she felt guilty. These were considered to be real crimes.

The real crimes that the participant committed involved knocking a friend's TV off a refrigerator and not taking responsibility for it, lying to a friend about what she was planning to do on New Year's Eve (and thus avoided being with the friend), lying to a potential date about being grounded because she didn't want to go on a date with him, lying to her mother about drinking, and an additional story the participant did not want revealed. The author constructed five additional stories which had no relevance to the participant's life. For example, the stories involved a breaking and entering crime, murder of a spouse following a suspected

affair, a covered up death following a hit and run, stealing money at a New Year's Eve party with friends and shoplifting during Christmas.

EEG data were gathered continuously, first during an eyes-closed, resting condition, then while the participant was asked to experience anxiety, and then while listening to stories orally presented by the examiner (lasting 45 to 120 seconds). The reading of the stories alternated between reading the five false crimes and then the five true crimes (i.e., false crime, true crime, false crime, etc.). This allowed for analysis of changes across repetitions. However, in this study, only the first exposure to the stories was subsequently employed in the analysis. The possible habituation of response pattern was not examined. The participant's eyes were closed in all conditions and instructions were: relax, with your eyes closed (condition one), allow yourself to be anxious (condition two), listen (conditions three and four), and block the stories (condition five).

Statistical Procedures

For the four comparisons the means and standard deviations (SD) of the (a) condition (test condition) were obtained. The mean of the (b) condition (control condition) then was compared to the (a) condition, employing the SD of the (a) condition. For example, the mean and SD of the (a) condition were employed to calculate the Z score increase of the variable when the participant experienced anxiety (b) condition. The figures present the standard deviation differences for the variables. The criteria for significance were a greater than one SD increase from the (a) to the (b) conditions.

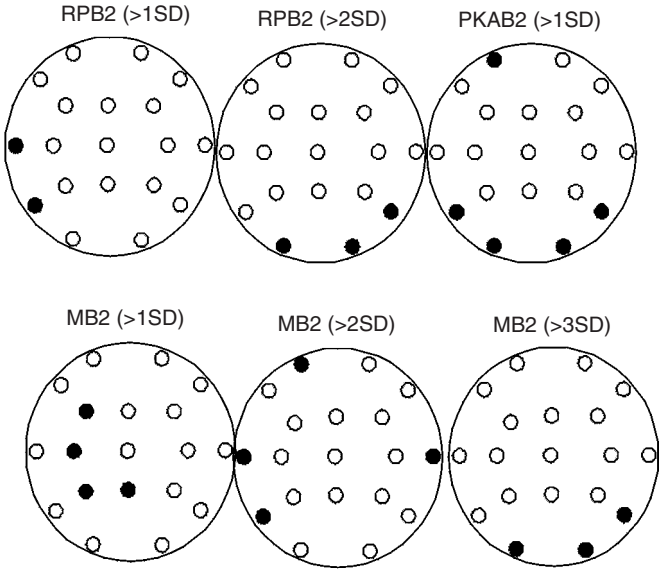
RESULTS

Listening to a real crime was compared to listening to a false crime, blocking while a real crime is read, and the anxiety condition. The anxiety condition was also compared to an eyes closed rest baseline. Spectral means were compared by using the standard deviation of the control condition. The control condition is listed first in each figure. Darkened circles in each figure represent preferential activation at this location from control to test condition. It is of some interest to note that the coherence and phase measures did not provide any significant results.

Eyes-Closed Resting Condition vs. Anxious Condition

Figure 1 presents the comparison between the eyes-closed resting condition and the anxious condition. This comparison indicated all significant activations were in the higher Beta frequency range (32-64 Hz) especially in posterior regions (nine total activations at O1, O2 and T6 in particular). In addition, consistent (across different measures) activations were noted in the T3-T5 section and T4. There were 13 significant variables in the left hemisphere and seven in the right hemisphere. The participant provided an intensity rating of 8 (out of 10) for the anxious feeling. Only the participant's statement was relied upon for this experience.

FIGURE 1. Eyes-Closed Resting Condition vs. Anxious Condition

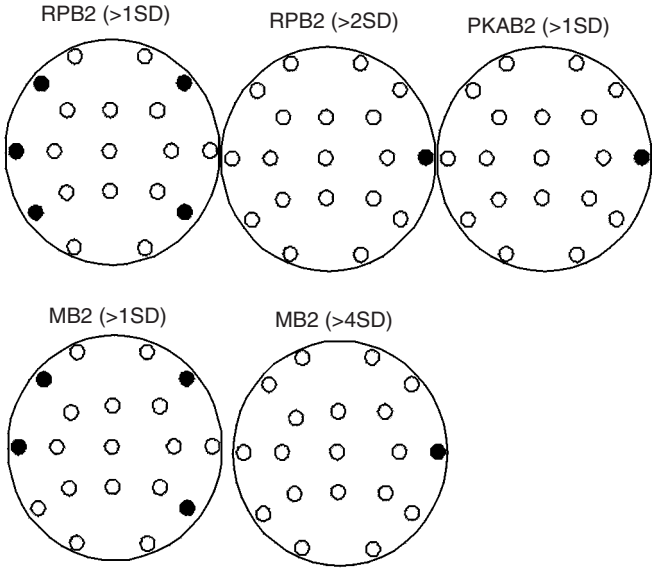


Blackened Circles indicate that the location was different from the comparison condition by the amount specified above the individual head figure.
RPB2: Relative Power Beta2 PKAB2: Peak Amplitude Beta2 MB2: Magnitude Beta2
Beta1: 13-32 Hz Beta2: 32-64 Hz
>1SD: greater than 1 Standard Deviation
>2SD: greater than 2 Standard Deviations
>3SD: greater than 3 Standard Deviations

Hearing False Crimes vs. Real Crimes

Figure 2 presents the comparison between the hearing false crimes and hearing real crimes condition. This comparison points to a frontal/temporal activation pattern in the higher frequency (32-64 Hz) occurring along the F7-T3-T5 and F8-T4-T6 paths. The strongest (in terms of standard deviations) activation was the T4 location with the peak amplitude of Beta2 providing a greater than two standard deviations difference and the magnitude Beta2 measure showing a greater than four standard deviation difference from the hearing false crimes condition. There were five significant activations in the left hemisphere and seven in the right hemisphere.

FIGURE 2. Hearing False Crimes vs. Hearing Real Crimes

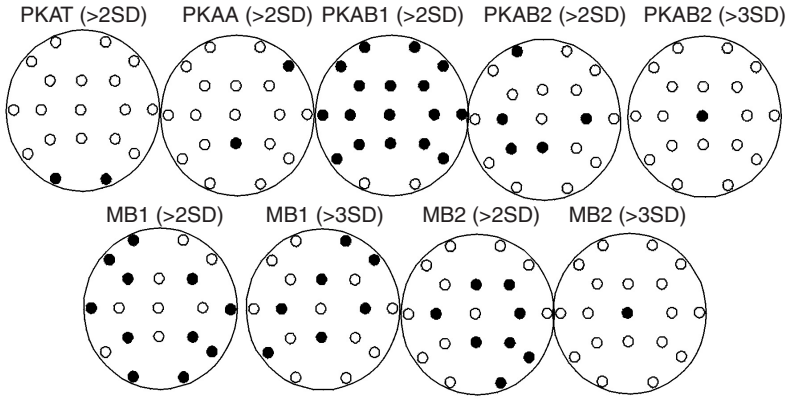


Blackened Circles indicate that the location was different from the comparison condition by the amount specified above the individual head figure.
RPB2: Relative Power Beta2 PKAB2: Peak Amplitude Beta2
MB2: Magnitude Beta2
>1SD: greater than 1 Standard Deviation
>2SD: greater than 2 Standard Deviations
>4SD: greater than 4 Standard Deviations

Hearing a Real Crime vs. Trying to Block While Hearing a Real Crime

Figure 3 presents the comparison between the hearing a real crime and trying to block the examiner's message while hearing a real crime. When the participant tried to block the real crime story, the pattern of response was a much more centrally located activation pattern and minimal activation of the T4 location. The participant reported that she was trying to block the incoming information by distracting herself with other thoughts. Furthermore, the response pattern was bilateral (20 in the left hemisphere and 22 in the right hemisphere), and was more centrally located (30 in central locations and 24 in more laterally located positions). Whereas in the first two comparisons all the significant results were focused on the Beta2 bandwidth, this comparison resulted in a preponderance of differences in the Beta1 bandwidth.

FIGURE 3. Hearing a Real Crime vs. Trying to Block When Hearing a Real Crime



Blackened Circles indicate that the location was different from the comparison condition by the amount specified above the individual head figure.
PKAT: Peak amplitude Theta PKAA: Peak Amplitude Alpha
PKAB1: Peak Amplitude Beta1 PKAB2: Peak Amplitude Beta2
MB1: Magnitude Beta1 MB2: Magnitude Beta2
Beta1: 13-32 Hz Beta2: 32-64 Hz
>2SD: greater than 2 Standard Deviations
>3SD: greater than 3 Standard Deviations

Anxiety Condition vs. Hearing a Real Crime

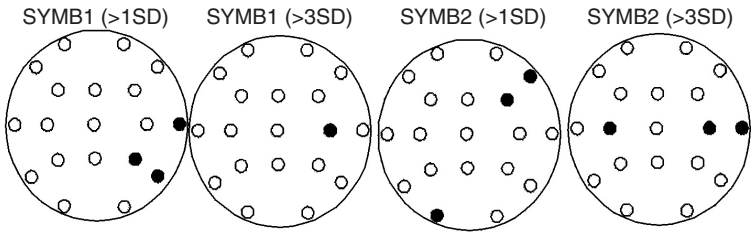
Figure 4 presents the comparison between the anxiety condition and hearing a real crime. In this comparison, the participant's response to the real crime was more focused on the T4 and C4 locations. The right hemisphere pattern was considerably more prevalent as there were only two activations in the left hemisphere and nine in the right hemisphere. All of the significant findings involved symmetry measures (both Beta1 and Beta2 bandwidths).

DISCUSSION

This participant presented a unique set of responses to the different cognitive/emotional tasks. Generally, all the tasks elicited activity in the higher Beta frequency range (32-64 Hz). The author's experience in artifacting was relied upon to discern EMG artifact and delete the affected epochs from analysis. However, EMG artifact could be considered a relevant source of information in the lie detection situation, as it could indicate tension reflected in the muscle system. A participant may characteristically tighten muscles in the neck when they lie, the so-called "tell" involved in poker games.

Temporal lobe activity appeared to be an especially significant issue in this case. The experience of anxiety raised posterior Beta2 activity in

FIGURE 4. Anxiety Condition vs. Hearing Real Crimes



Blackened Circles indicate that the location was different from the comparison condition by the amount specified above the individual head figure.
SYMB1: Symmetry Beta1 SYMB2: Symmetry Beta2
Beta1: 13-32 Hz Beta2: 32-64 Hz
>1SD: greater than 1 Standard Deviation
>3SD: greater than 3 Standard Deviations

more left hemisphere/posterior locations along the occipital-temporal locations. Temporal activations were confined to the left temporal location (T3) and there was a left hemisphere focus to the activations. As the participant listened to real crimes (vs. false crimes) the focus of the activations shifted to the right temporal location (T4). The focus of the activations was in the right hemisphere, a pattern different from the anxiety condition. From this line of reasoning, guilt may be seen as a right hemisphere (in particular, right temporal) activation pattern and anxiety as a left hemisphere/posterior pattern. Figure 3 (anxiety vs. real crime) further supports the concept that guilt has a right hemisphere manifestation (all symmetry measures).

When the participant attempted to block the inflow of the message (Figure 3), she activated the central locations apparently by creating internal thought patterns. The separation of anxiety from guilt is clear in Figure 4 and strongly points to a right hemisphere–and in particular a right temporal involvement in the experience of guilt. In this participant, the qEEG approach to the lie detection problem has provided encouraging results for further research and development.

REFERENCES

Ben-Shakur, G., & Furedy, J. J. (1990). *Theories and applications in the detection of deception.* New York: Springer-Verlag.

Cestaro, V. L. (1996). *A comparison of accuracy rates between detection of deception examinations using the polygraph and the computer voice stress analyzer in a mock crime scenario*. (Report No. DoDPI95-R-0004). Washington, DC: Department of Defense Polygraph Institute.

Cestaro, V. L., & Dollins, A. B. (1994). *An analysis of voice responses for the detection of deception*. (Report No. DoDPI94-R-0001). Washington, DC: Department of Defense Polygraph Institute.

Fienberg, S. (Chair). (2002). *The polygraph and lie detection.* Committee to review the scientific evidence on the polygraph, NASA Report, 2002. Washington, DC: The National Academies Press.

Janniro, M. J., & Cestaro, V. L. (1996). *Effectiveness of detection of deception examinations using the computer voice stress analyzer* (Report No. DODPI96-R-0005). Washington, DC: Department of Defense Polygraph Institute.

MacLaren, V. V. (2001). A quantitative review of the guilty knowledge test. *Journal of Applied Psychology*, *86*, 674-683.

Marston, W. M. (1917). Systolic blood pressure changes in deception. *Journal of Experimental Psychology*, *2*, 143-163.

Rosenfeld, J. P., Angell, A., Johnson, M., & Qian, J. H. (1991). An ERP-based, control-question lie detector analog: Algorithms for discriminating effects within individuals' average waveforms. *Psychophysiology*, *28*, 319-335.

Thornton, K. (1995). The anatomy of the lie: A QEEG investigation into lie detection. *Journal of Offender Rehabilitation*, *22* (3/4), 179-210.

Trovillo, P. V. (1939). A history of lie detection. *Criminology and Police Science*, *29*, 848-881.