J Forensic Sci, Jan. 1978, Vol. 23, No. 1

J. F. T. Corcoran,[1] *M.D. (Lt. Col., USAF, MC); M. D. Lewis,*[2] *M.D. (Major, USAF, MC); and R. B. Garver,*[1] *Ed.D. (Major, USAF, BSC)*

Biofeedback-Conditioned Galvanic Skin Response and Hypnotic Suppression of Arousal: A Pilot Study of Their Relation to Deception

Since early civilization man has tried to separate reality from fantasy, fact from speculation, and truth from deception. Shakespeare [*1*] wrote, "Time's glory is to calm contending kings, to unmask falsehood and bring truth to light. . . ."

Early efforts combined folklore with superstition. Trial by ordeal rested upon the belief that God would intervene with a sign or miracle to determine the question at issue between two contending parties. This belief is almost universally found in primitive races and is typically tested with an established rite or ritual. Thus one who could carry red-hot iron, or plunge his hand into boiling water, or sink when thrown into water was thought to have right on his side [*2*]. Later it was also thought that drugs could unlock withheld truths; the most ancient of all drugs used for this purpose was alcohol. The Romans coined a proverb, "In Vino Veritas." Within the past 150 years several drugs have at one time or another been erroneously used and referred to as "truth serums." Hashish, cocaine, mescaline, scopolamine, and amytal were but a few [*3*]. Their use rapidly diminished, in part by their recognized unreliability and in part with the advent of apparatus that measured physiologic responses. It was generally thought then, as it is now, that these measurements when interpreted properly could make a distinction between truth and deception.

In 1895 Lombroso [*4*] attempted to judge the veracity of statements made by criminal suspects through the use of the "hydro sphygmograph," a machine which measured blood pressure and pulse changes. Later, in 1914, Benussi [*5*] experimented with a pneumatic chest tube to record changes in respiration and concluded he could distinguish when a subject lied by examining the length of inspiration divided by the length of expiration. This finding and Lombroso's much earlier observation were eventually combined into one apparatus in 1921 by an American police officer, John A. Larson [*6*]. He called the machine a polygraph. By 1926 Leonard Keeler, a junior collaborator of Larson, had added galvanic skin response to the Larson machine, which recorded the blood pressure, pulse, and respiration [*7*].

The views expressed herein are those of the author and do not reflect the views of the United States Air Force or the Department of Defense. Received for publication 4 March 1977; revised manuscript received 31 May 1977; accepted for publication 3 June 1977.

[1]Chief and staff psychologist, respectively, Adult Outpatient Mental Health Clinic, Department of Mental Health, Wilford Hall USAF Medical Center, Lackland AFB, Tex. 78236.

[2]Chief, Department of Mental Health, United States Air Force Academy, Colo. 80840.

During the past 50 years polygraph interrogation has become a burgeoning industry; its use ranges from criminal interrogation to a preemployment screening device. Conservative estimates count several million polygraph examinations yearly by approximately 3000 professional polygraphers [*8*].

In view of such widespread use, the consequences of which are typically quite serious, accuracy of this procedure becomes a crucial consideration. It is generally held that lying is accompanied by specific physiologic or behavioral alterations, or both. The most common physiologic alterations measured have been respiration, relative blood pressure, and galvanic skin response. While laymen may refer to the polygraph as a lie detector, it is nonetheless no more than a recording device of psychophysiologic responses. In looking at an examiner's ability to identify physiologic responses via the polygraph, Edel and Jacoby [*9*] found a 95% overall agreement among ten experienced examiners who worked independently on 40 polygraph interview cases involving 2530 separate questions. It is an impressive figure but, as the authors point out, identification of the presence or absence of specific physiologic reactions is not equivalent to consistency in interpretation and conclusions.

In addressing the problem of the validity and reliability of the polygraph, Abrams [*10*], in an extensive review of the literature in 1972, concluded: "The findings of this review indicate that the polygraph approach is a valid and reliable method for detecting deception." In terms of raw figures, comparison of studies are difficult, if not impossible. The variables in experimental design, settings, and operations almost preclude a meaningful comparison. Nonetheless, the literature reflects studies such as that of Summers [*11*], who reported 98 to 99% accuracy in his laboratory work with the polygraph. Reported accuracy in that range is not unusual, and according to Orlansky [*12*] in a 1962 review, accuracy reporting below 75% is rare. Validity and reliability, despite the optimistic reports of commercial operators, are very much in dispute. The American Civil Liberties Union in a report filed with the Committee on Government Operations (U.S. House of Representatives) [*13*], reviewed polygraph testing in considerable depth. They write, "A number of recent expert studies have concluded that the polygraph has little, if any, scientific validity."

Whatever accuracy a particular polygraph operator might have, we were curious to see if that accuracy could be significantly diminished through training and subsequent modification of the responses measured by the polygraph.

Of the many indicators used to measure autonomic activity, the galvanic skin response (GSR) is thought by many to be one of the most sensitive measurements and is considered superior to other variables [*14–18*]. It is not without its critics, particularly among field personnel, some of whom regard its effectiveness as inadequate [*6,19*]. In the laboratory setting, however, it appeared to be at least as accurate, if not more accurate, than other physiologic sensors; this observation motivated us to work with this indicator.

Our hypothesis was to determine if conditioning of GSR by biofeedback technique would assist subjects to avoid detection. Similarly, we sought to answer this question as well as provide another technique for comparative purposes using hypnosis in suppression of the arousal state.

Experimental Design

Biofeedback is a general term used to describe the feedback of physiological information via some measuring device to a subject. The subject may then use this information as a reinforcer to change a desired feature. One example has been the use of an electromyograph to feedback skeletal muscle tension to a subject who then controls the muscle tension. This electromyographic feedback is useful in treating tension headaches and torticollis and in the rehabilitation of muscles. Recently, biofeedback has expanded to in-

clude the training of autonomic or visceral functioning. Authors have reported control of heart rate [*20*], electrodermal activity (GSR) [*21*], gastric acid secretion in ulcer patients [*22*], and blood pressure [*23*]. In principle, if a physiological response is directly and efficiently measurable, it is possible to change and control that response.

Visceral learning or training via biofeedback has been described by Shapiro and Schwartz [*24*] as a feedback-operant model. That is, the reinforcer (reward) serves to strengthen the response that follows. This model has three main goals: (1) the development of increased awareness of the relevant internal physiologic functions or events via the measuring device; (2) the establishment of control over those functions or events, and (3) the transfer or generalization of that control from the training site to other areas of the patient's life. Because this model has been used to control GSR we felt it would be possible to teach a subject to control his arousal sufficiently to deceive a polygraph operator and not be detected.

There is substantial evidence in the literature to indicate that hypnosis or hypnotic suggestion can also exercise extensive control over the autonomic nervous system. Deabler et al [*25*] conducted a study using relaxation and hypnosis to lower high blood pressure. Vasomotor control, another autonomic function, has been reported numerous times in the literature and shows that hypnotic suggestion can substantially influence blood shunting and hemostasis. Dubin and Shapiro [*26*] demonstrated the use of hypnosis to facilitate dental extraction and hemostasis in a hemophilic patient.

Garver [*27*] has reported several case studies of hypnotic training to control arousal level in increasing human performance and used the following method to train his subjects to control their arousal level hypnotically. An arousal level from one to ten is established for the subject. Zero is set as the lowest possible arousal level, similar to a deeply relaxed state or even a sleep state. The subject is then taken numerically and experimentally through the next nine arousal levels, experiencing the sensations and experiences associated with each level. Once the subject under hypnosis is able to associate the arousal state with the appropriate numerical designator and is able to control his arousal levels, the next step is to use the posthypnotic suggestion that the subject will be able to recognize, as most of us can, where he is on the arousal scale. The individual can usually quite accurately describe, on a scale of one to ten, how he feels, using five as the numerical designator for his own personal optimal arousal level. If the individual feels that he is too excited or "psyched up" he perceives himself as being at seven or eight, in which case he begins to count repeatedly, "seven, seven, seven, six, six, six, five, five, five." During this time, he experiences the sensation of lowering his arousal level. Too often the general sugestion, "I must calm myself down or relax," may send the individual toward the opposite direction. Using the numerical designators as posthypnotic cues to his unconscious mind, the individual is able to eliminate conscious interference and screening of the suggestion for arousal level change.

Garver's work [*27*] indicates that quite often arousal level control is simply a matter of conditioning the autonomic nervous system and substituting productive patterns for unproductive ones. The implication of this type of autonomic nervous system control is clear for this study where autonomic responses are the physiological indexes used in the polygraph examination.

Method

Subjects

Thirty subjects, 19 males and 11 females, volunteered for the experiment. These subjects had no previous biofeedback or relaxation training. Their average age was 31.3 years, and they had an average of 16 years of education.

Apparatus

The polygraph used was a Stoelting three-channel Emotional Stress Monitor, Model #22600, which measured blood pressure, heart rate, respirations, and GSR. The responses were recorded on a strip chart, with both blood pressure and heart rate read from one channel while respiration and GSR were interpreted from separate channels. The biofeedback trainer was Biofeedback Technology Inc. Model 701 (BFT 701), which measures GSR. The response was fed back to the subject visually via a meter and audibly by a variable tone.

Procedure

A pretest baseline consisting of three trials per subject was established for each of the 30 subjects.

The subject was seated in the test room and given an introductory explanation of the polygraph and its functions by the operator. The subject was then prepared for the three trials by being attached to the polygraph. A blood pressure cuff was placed on one arm; GSR electrodes were placed on two fingers; and a pneumograph bellows was attached around the subject's thorax. In each trial, the subject was presented with four 76 by 127-mm (3 by 5-in.) index cards. In the first trial a neutral number, and in the other two trials a neutral color or letter, was written on the index card. The subject was asked to choose one of the four cards and maintain possession of the chosen card during the trial. The subject was instructed to answer no to each of the choices presented when asked if he chose that card, thus forcing the subject to deceive the examiner. During the subject's answer, his physiological response was recorded on the polygraph. Ten responses were elicited, but the first three choices and the last three choices were not among cards given the subject. This allowed the initial physiological arousal during each trial to decrease and not contaminate the results as well as provide a comparative baseline. The last three bogus choices allowed the polygraph examiner a period of decreased arousal by which to judge the other responses.

After the three trials the polygraph examiner reviewed the physiological responses and called on which "no" response the subject had deceived him. He was allowed to make a "no call," which meant that the response was not clear enough to detect deception. The examiner was then scored on the number of "hits" or "misses" he made in detecting deception. A hit meant he had accurately detected deception and a miss meant he did not detect the deception.

After the pretest the subjects who were least successful in deceiving the examiner were selected for the biofeedback group. Hypnosis and control groups were then selected. During the training period for the hypnosis and biofeedback groups the control group received no training.

The seven subjects in the hypnosis group received specific training that taught the subjects to use autohypnotic suggestion designed to distort the physiological indexes measured by the polygraph. The autohypnotic suggestion was aimed at manipulating the arousal level autogenously to maintain a calm state throughout the examination or to elevate the arousal level at will to produce false indexes. This training was accomplished by each subject for the same period of time allotted to the biofeedback group and the control group.

The ten subjects in the biofeedback group received training aimed at teaching them to control their arousal by controlling their GSR. They received 30 min of training three times per week. On the days the subjects did not receive training they were asked to listen to a 15-min tape that contained a relaxation exercise. During the training periods they were fed back their GSR via the BFT 701 GSR trainer. The goals of this training were first, to teach the subject to decrease his arousal and second, to teach him control sufficient to have him increase his GSR at will. The time of training was four weeks.

After the training period a test was done on all three groups. This test was exactly like the pretest except a different set of neutral numbers, colors, and letters were used. The polygraph operator was unaware of which group each subject was in, and he was not given feedback as to whether he hit or missed on any trial. Again, the operator was allowed to "no call" with insufficient data. Hits and misses were scored in the same manner as the pretest.

Results

An analysis of variance was done with performance on the polygraph (hit, miss, or no call) as the dependent variable and group (control, hypnosis, and biofeedback), target (number, letter, and color), and mode used to call (respirations, GSR, and blood pressure plus heart rate) as independent variables. In addition, age, sex, and education were analyzed. The analysis of variance run for the experimental condition indicated one significant main effect. Results were statistically significant only when a subject was identified by group assignment, that is, control, hypnosis, or biofeedback ($f = 4.82, P < 0.05$; see Table 1). Effects of target or method of call were not significant and neither were two-way

TABLE 1—*Results of general linear model analysis.*

Source	P^a	R	R^b	f	df	Restricted Model for Comparison
1. Group	2	0.33739	0.11383	4.82[c]	2,75	0[b]
2. Target	2	0.07276	0.00529	0.20	2,75	0
3. Method	6	0.21151	0.04474	0.55	6,71	0
4. Group + target	4	0.34515	0.11913	2.47	4,73	0
5. Group + method	4	0.41636	0.17335	1.81	8,69	0
6. Target + method	6	0.21968	0.04826	0.44	8,69	0
7. Group × target	8	0.40535	0.16431	0.95	4,70	4
8. Group × method	20	0.54012	0.29173	0.61	16,58	5
9. Target × method	20	0.24001	0.05760	0.01	16,58	6
10. Age + education + sex	3	0.09190	0.00844	0.21	3,74	0

[a] Number of independent predictors in model (that is, total number minus 1).
[b] 0 is overall mean (that is, no effect).
[c] $P < 0.05$.

interactions (Table 2). Further, age, education, and gender were not significantly related to performance on the polygraph (Table 1).

After the pretest run subjects for biofeedback were selected on the basis of their having been correctly identified more frequently by the polygraph operator during their deception, whereas both the control and hypnosis groups had subjects who were capable of deceiving the polygraph operator prior to any training. This method of selection resulted in a skewing of the sample because of the nonrandom selection of the biofeedback group. While the control group and the hypnosis group showed no difference in their pretest performance, the biofeedback group had a statistically greater number of correctly identified "deceivers" ($\chi^2 = 7.32; P<0.05$).

Both the hypnosis and biofeedback groups had more females than the control group, and the hypnosis group was older and less educated than the control group. Biofeedback participants were younger and more educated than the controls. Despite significant differences of the hypnosis and biofeedback groups when compared to the control

TABLE 2—*Correlations between groups and methods.*

Method	Control	Hypnosis	Biofeedback
Respirations	0.04	0.10	−0.13
GSR	0.12	−0.02	−0.10
Blood pressure plus heart rate	0.04	−0.09	0.04
Respirations + GSR	0.06	0.02	−0.08
Respirations + blood pressure plus heart rate	−0.06	0.04	0.03
GSR + blood pressure plus heart rate	−0.03	−0.04	0.06
Respirations + GSR + blood pressure plus heart rate	−0.11	0.11	0.01

group, none of the background variables depicted in Table 3 were significant in fooling the operator.

Table 4 compares pretest and final results. The tests differed only in terms of training given to two of the three groups. Both the hypnosis and the biofeedback group were successful in fooling the polygraph operator after training. The increase in misses by the operator following training by the two groups was statistically significant at the following levels: hypnosis, $\chi^2 = 25.22$ and $P < 0.001$; and biofeedback, $\chi^2 = 21.33$ and $P < 0.001$.

TABLE 3—*Correlations between groups and background variables.*

Variable	Control	Hypnosis	Biofeedback
Age	−0.07	0.37[a]	−0.25[a]
Education	0.12	−0.49[a]	0.29[a]
Sex (1 = female)	0.09	0.36[a]	0.41[a]

[a] $P < 0.05$.

TABLE 4—*Comparisons between pretest and final test results.*

Group	Comparison
Control	not significant
Hypnosis	$\chi^2 = 25.22; P < 0.001$
Biofeedback	$\chi^2 = 21.33; P < 0.001$

Pretest and final test analysis of the control group did not differ at a significant level. Because of nonrandom assignment of subjects no conclusions may be made concerning the effectiveness of hypnosis versus biofeedback as a means of deceiving a polygraph operator. Members of the hypnosis and biofeedback groups differed significantly in the pretest ($\chi^2 = 7.32$, $P < 0.05$) because of method of selection. This experimental bias precluded final test comparison regarding which group performed better.

As a final note, we are not prepared on the basis of a single pilot study to extrapolate from the laboratory to a field condition. The variables are many. What we suggest is that some of the sensors traditionally used to measure deception can be brought under volitional control by subjects with adequate time and rather simple training.

Summary

In this study of biofeedback-conditioned suppression of galvanic skin response and hypnotic suppression of an arousal state and the relationship of these two techniques to the detection of deception by the polygraph, 30 subjects were given a series of card tests with an experienced polygraph operator identifying which number, letter, or color a subject had selected. Seven subjects were then trained with autohypnosis, 10 subjects were trained with biofeedback, and 13 subjects received no training. After 17 of the 30 subjects were trained, all 30 subjects were retested with the same protocol as the first test. The 17 trained subjects were able to deceive the operator and remain undetected at a statistically significant level while the ability to deceive on the part of the control group showed no significant change.

Acknowledgments

We wish to express our appreciation to personnel at Ft. Sam Houston Field Office, Third Region, U.S. Army, Criminal Investigation Command, Ft. Sam Houston, Tex.; Hendrick Ruck, occupational survey analyst, and Captain David S. Vaughan, USAF, chief, Test Research Section, at the USAF Occupational Measurements Center, Lackland AFB, Tex.; and MSgt. Emory Wyatt of the Adult Outpatient Mental Health Clinic, Department of Mental Health, Wilford Hall USAF Medical Center, Lackland AFB, Tex.

References

[1] Hubler, E., Ed., *Shakespeare's Songs and Poems*, McGraw-Hill, New York, 1959, p. 473.
[2] Holdsworth, W., *History of English Law*, Methuen, London, 1966, p. 310.
[3] Robin, J., *Police Drugs*, Philosophical Library, New York, 1956.
[4] Lombroso, C., *L'Homme Criminal*, Vol. 2, 1895, pp. 336-346.
[5] Benussi, V., "Die Atmungssymptome der Luge," *Archiv für Gesamte Psychologie*, Vol. 31, 1914, pp. 244-273.
[6] Reid, J. and Inbau, F., *Truth and Deception: The Polygraph ("Lie Detector") Technique*, Williams & Williams, Baltimore, 1966.
[7] Keeler, L., "A Method for Detecting Deception," *American Journal of Police Science*, Vol. 1, 1930, pp. 38-51.
[8] Lykken, D., "Psychology and the Lie Detector Industry," *American Psychologist*, Oct. 1974, p. 725.
[9] Edel, E. and Jacoby, J., "Examiner Reliability for Polygraph Chart Analysis: Identification of Physiologic Responses," *Journal of Applied Psychology*, Vol. 65, No. 5, 1975, pp. 632-634.
[10] Abrams, S., "Polygraph Validity and Reliability: A Review," *Journal of Forensic Sciences*, Vol. 18, No. 4, Oct. 1973, pp. 313-326.
[11] Summers, W., "Science Can Get the Confession," *Fordham Law Review*, Vol. 8, 1939, pp. 335-354.
[12] Orlansky, J., "An Assessment of Lie Detection Capability," Technical Report 62-16, Institute of Defense Analysis, Research and Engineering Support Div., Springfield, Va., July 1964.
[13] *The Use of Polygraphs and Similar Devices by Federal Agencies*, U.S. Government Printing Office, Washington, D.C., 1974, p. 36.
[14] Ellson, D., Davis, R., Saltzman, I., and Burke, C., "A Report of Research on Detection of Deception," Office of Naval Research Contract N6 ONR-18011, prepared by Indiana University, Bloomington, 1952.
[15] Kubis, J., "Studies in Lie Detection: Computer Feasibility Considerations," Technical Report 62-205 under Air Force Systems Command Contract AF30 (602)-2270, Project 5534, prepared by Fordham University, New York, 1962.
[16] Kugelmass, S. and Lieblich, I., "Effects of Realistic Stress and Procedural Interference in Experimental Lie Detection," *Journal of Applied Psychology*, Vol. 50, 1966, pp. 211-216.
[17] Thackray, R. and Orne, M., "A Comparison of Physiological Indices in Detection of Deception," *Psychophysiology*, Vol. 4, 1968, pp. 329-339.
[18] Violante, R. and Ross, S., "Research in Interrogation Procedures," Report 707-65, Office of Naval Research, Defense Documentation Center No. AD-467624, Stanford Research Institute, Menlo Park, Calif., Oct. 1964.

[19] Orne, R., Thackray, R., and Poskewitz, D., "On the Detection of Deception," in *Handbook of Psychophysiology,* N. Greefield and R. Steinback, Eds., Holt, Rhinehart, and Winston, New York, 1972, pp. 743-785.

[20] Wells, D. T., "Large Magnitude Voluntary Heart Rate Changes," *Psychophysiology,* Vol. 10, No. 3, 1973, pp. 160-269.

[21] Klinge, V., "Effects of Exteroceptive Feedback and Instructions on Control of Spontaneous Galvanic Skin Response," *Psychophysiology,* Vol. 9, 1972, pp. 305-317.

[22] Welgan, P. R., "Learned Control of Gastric Acid Secretion in Ulcer Patients," *Psychosomatic Medicine,* Vol. 36, No. 5, 1974, pp. 411-419.

[23] Blanchard, E. B., "Clinical Applications of Biofeedback Training," *Archives of General Psychiatry,* Vol. 30, May 1974, pp. 573-589.

[24] Shapiro, D. and Schwartz, G., "Biofeedback and Visceral Learning: Clinical Application," *Seminars in Psychiatry,* Vol. 4, 1972, pp. 171-184.

[25] Deabler, H. L., Dillenkoffer, R. L., and Elder, S. T., "The Use of Relaxation and Hypnosis in Lowering High Blood Pressure," *The American Journal of Clinical Hypnosis,* Vol. 16, 1973, pp. 75-83.

[26] Dublin, L. L. and Shapiro, S. S., "Use of Hypnosis to Facilitate Dental Extraction and Hemostasis in a Classic Hemophiliac with High Antibody Titer to Factor VIII," *The American Journal of Clinical Hypnosis,* Vol. 17, 1974, pp. 79-83.

[27] Garver, R. B., "The Enhancement of Human Performance with Hypnosis Through Neuromotor Facilitation and Control of Arousal Level," *The American Journal of Clinical Hypnosis,* Vol. 19, No. 3, Jan. 1977, pp. 177-181.

Address requests for reprints or additional information to
James F. T. Corcoran, Lt. Col., USAF, MC
Department of Mental Health
Wilford Hall USAF Medical Center
Lackland AFB, Tex. 78236.