A STUDY OF THE RELATIVE EFFECTIVENESS OF PHYSIOLOGICAL DATA IN FIELD POLYGRAPH EXAMINATIONS

By

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Abstract

From 122 sets of charts, all confirmed as either truthful or deceptive, information was obtained about the effectiveness of each of the four recorded channels of physiological information. The test format was quadri-zone and the tests were either conducted at the Buffalo Police Department or the Matte Polygraph Service, Inc. Of those original tests, 62 were called "deception indicated" (DI) and 53 "no deception indicated" (NDI). Subsequently these decisions were verified as correct. In addition, there were seven inconclusive decisions, of which five proved to be innocent and two guilty. The instruments were electronically enhanced four-channel Stoelting polygraph units which recorded abdominal and thoracic respiration, electrodermal (GSR), and cardiovascular activity.

The most productive of the physiological channels was the pneumo tracing at 43%, followed by the cardio at 32% and the electrodermal at 24%. Among men, the most productive channel for the innocent cases was the pneumo at 67%, the cardio at 22%, and the electrodermal at 11%. For guilty men the most productive was the cardio at 46%, the pneumo at 37%, and the electrodermal at 15%. Among innocent women the most productive was the electrodermal at 43%, the pneumo at 38%, and the cardio at 18%. For guilty women the most productive channel was the pneumo at 44%, the cardio at 39%, and the electrodermal at 17%.

Other combinations of truth and deception, effectiveness of each channel, and their interaction with gender are explored. Many of the differences reach statistical significance.

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Relative Effectiveness of Physiological Data in Field Polygraph Examinations

Background

This author (Matte) attended the Backster School of Lie Detection in 1972 and there learned that male polygraph subjects were predominantly stomach or abdominal breathers and female subjects were predominantly chest or thoracic breathers. At that time this was especially meaningful because a great percentage of polygraph instruments had only one pneumograph channel which was mechanical rather than electronic requiring a decision as to where to place the single pneumograph component. The administration of several thousand polygraph examinations by this author (Matte) using polygraph instruments that contained double pneumograph components which recorded both stomach or abdominal breathing patterns and chest or thoracic breathing patterns appeared to support the teachings of the Backster School.

In August 1986 at the 21st Annual APA Seminar at Smuggler's Notch, Jeffersonville, Vermont, a presentation was made by Dr. Gordon H. Barland in reporting on research he had conducted regarding the effectiveness of the pneumograph versus the GSR and the Cardiograph. Barland showed several polygraph charts projected on a screen which reflected significant physiological arousals at a particular stimulus marking in the GSR and Cardio tracings but none in the pneumograph tracing. Barland had used only one pneumograph in this experiment because in order to use the plethysmograph he had to sacrifice one of the pneumograph channels. The message conveyed by Barland's presentation was that the pneumograph had been ineffective in identifying deception compared to GSR and Cardiograph tracings. The subject sample in Barland's experiment consisted of six males and six females. Barland had positioned the single pneumograph component over the chest of the male subjects and under the breast of the female subjects.

In a research project conducted for the National Institute of Law Enforcement and Criminal Justice, by Drs. David Raskin, Gordon Barland and John Podlesny(1978), it was reported that the Galvanic Skin Response was clearly superior to the pneumograph and cardiograph both in laboratory experiments and with criminal suspects in field situations. It was further stated that the cardio and respiration measures showed significant identification of innocent but not guilty subjects, but it was noted that in Experiment II the respiration was measured with a device different from that typically employed in the laboratory or field, and the cardio was measured using a low-pressure cuff at an inflation pressure between 50 and 60 mmHg. There is no mention of the sex of the subjects and the location of the pneumograph component on the subjects' person. In Experiment I it is reported that both thoracic and abdominal respiration were recorded and measured and both measures of respiration produced clear indications of greater suppression in respiration amplitude following relevant questions for guilty subjects and control questions for innocent subjects. Thoracic respiration showed an increase in amplitude following relevant questions for innocent subjects but a similar effect did not occur in abdominal respiration. However, there is no mention of the sex distribution of the subjects used in this experiment.

In subsequent research conducted by Brian C. Jayne (1990) involving quantitative analysis of 100 verified sets of field polygraph records, the results indicated that respiration, electrodermal, and cardiovascular

parameters each provide significant discrimination between truthful and deceptive subjects. The combined evaluations of these three parameters provided an accuracy and conclusive rate which was higher than the analysis of any individual parameter. However, the respiration parameter yielded the most consistent and accurate discrimination between truthful and deceptive subjects. There was no significant difference between false positive and false negative errors in the respiration or cardiovascular parameters. Conversely, the electrodermal (GSR) parameter produced the greatest number of errors, the highest overall inconclusive rate, and had a statistically significant rate of false negative errors. When inconclusive opinions are excluded, the optimum accuracy for respiration was 87%, for the cardiovascular 83%, for the GSR 69%. The respiration and cardiovascular measurements yielded no significant difference in accuracies between truthful and deceptive subjects, however the GSR yielded a false positive error rate of 21% and a false negative error rate of 41%. Since the three parameters each produced an independent accuracy which was significantly different from the other two parameters, Jayne went further and attempted to optimize the accuracy of the quantitative results by multiplying the total score of each parameter by a factor of its independent accuracy, but found that it did not significantly affect the accuracy of quantitative evaluations. It should be noted that in Jayne's research, the field polygraph instruments had a double-pneumograph and the test format was the Reid Control Question technique. A unique rank order scoring system was used by Jayne, with a view to incorporating it into a computer system. It bore more resemblance to the Horizontal Scoring System (Gordon and Cochetti) and the Rank Order Scoring System (Honts and Driscoll) than the traditional numerical methods. Excluding Inconclusive opinions, numerical scoring of polygraph charts produced an average accuracy of 92% with a 3% false positive result as opposed to the more common quantitative measurement method which yielded an average accuracy of 89% with a 2% false positive bias. The differences in accuracy, inconclusive results and distribution of false positive/negative errors between quantitative evaluation and numerical scoring was not statistically significant.

Richard I. Thackray and Martin T. Orne conducted a study (1968) using a mock paradigm to determine the effectiveness of several physiological parameters which included respiration, Galvanic Skin Response (GSR), Skin Potential Response (SPR), and systolic blood pressure. However they used only one pneumograph component which was positioned at the base of the subjects' rib cage. Thirty male students were used as subjects in this study. Furthermore, the cardiograph component consisted of a Beckman Fels Model Systolic Monitor, which employs a finger cuff and sensor which was attached to the first finger of the subject's right hand. This device was adjusted to yield a measure of systolic pressure approximately every fourth heart beat. The results of this study showed that the GSR and SPR were effective in significantly discriminating deception. Respiration revealed evidence of significant but inconsistent discrimination, while the systolic blood pressure did not perform better than chance. This study was designed only to identify the guilty; no innocents were used.

Stanley M. Slowik and Joseph P. Buckley conducted a study (1975) using thirty verified real-life cases wherein a Stoelting Polygraph instrument was used to record both abdominal and thoracic respiration, blood pressure/pulse

rate and galvanic skin reflex. This study measured the ability of seven well trained and experienced polygraphists in identifying the overall veracity of the thirty subjects by examining each polygraph tracing separately and then collectively. The results revealed an average accuracy of 87.2% when all three physiological indices were reviewed, but were only correct in 80.5% of the cases using respiration alone, 80.0% using the GSR alone, and 77.1% using only the cardiograph tracing. The polygraphists accuracy in making individual question decisions as to truth or deception resulted in 81.0% when using all three indices to evaluate the 141 individual test questions but the averages of the independent parameters were 77.5% for respiration, 73.5% for GSR and 72.9% for the cardiograph tracing.

In a laboratory study conducted by Robert J. Cutrow, Arthur Parks, Nelson Lucas and Kathryn Thomas (1972), several psychophysiological measures were used including respiration, Galvanic Skin Response (GSR), and heart rate, but did not record blood pressure changes, hence no blood pressure arm cuff was used. The single pneumograph component was positioned over "subject's lower sternum" for both male and female subjects, which may be interpreted to mean under the breast of females and over the lower chest of males. This study found that, using mock paradigms, only the GSR yielded a sex difference in that its detection of personal stimuli was significantly more successful than detection of involvement or neutral stimuli. However no data was given and there was no discussion of which sex was more affected by the GSR. It is unclear from the graphs of Table 1 as to which of the factors was most significant. Of the three parameters of interest in this study, the GSR was the most productive, followed by respiration, then heart rate. Interestingly, Cutrow, et al., mentioned that the heart rate increased in some deceptive subjects as expected but other deceptive subjects showed significant decrease in their heart rate in response to lie stimuli which they attribute to a milder arousal state possibly due to the subject being unimpressed by the experimental circumstances or perhaps possessing a higher arousal threshold. These findings regarding heart rate increase/decrease are similar to the results of an experiment conducted by this author (Matte 1980) wherein a blood pressure cuff was used which recorded both heart rate and blood pressure changes. However the cause for these differences in subject's heart rate responses are reported and explained by this author as physiological in nature rather than psychological.

Robert P. Ryan conducted a field study (1989) to replicate the Slowik/Buckley study of relative accuracy of polygraph parameters using a more objective design with the primary change being the use of a numerical scoring system of chart evaluation to replace the visual inspection method. A three-position scale of chart analysis as used rather than the seven-position scale as used in the Backster Tri-Zone and Matte Quadri-Zone Comparison Techniques. Unlike the Slowik/Buckley study which included Inconclusives as errors, Ryan tabulated the Inconclusives separately in order to address relative utility of each parameter. Furthermore, no minimums core or threshold was established to determine truth or deception; this decision was left to the discretion of the polygraphist. The primary reason cited was the use of a Secondary Relevant question also known as Secondary Control in the Reid Technique, which could dampen or be dampened by the more serious/stronger relevant questions contained in the same test. A Stoelting polygraph instrument which recorded both thoracic and abdominal respiration,

Galvanic Skin Response (GSR) and cardiovascular recording with a blood pressure cuff was used. The results revealed that the GSR was the most accurate parameter overall (87.6%) and with regard to the deceptive subjects the GSR was not only significantly more accurate than the cardio (64.6%) and respiration (67.7%) parameters, but also the combination of all three parameters used simultaneously (80.6%). However for the truthful subjects, respiration was accurate (81.0%), GSR (80.5%) and Cardio (66.7%), with an overall accuracy using all three parameters 92.5%. With truthful subjects the use of all three parameters proved to be significantly more accurate than the use of the GSR alone and significantly more accurate than both the cardio and respiration parameters. Regarding utility rate when inconclusives are omitted from the data, the respiration parameter was found to be significantly more useful than the GSR and the cardio parameters for both truthful (R 72.5%) (G 51.2%) (C 67.5%) and deceptive (R 81.2%) (G 60.0%) (C 60.0%) subjects. The use of all three parameters revealed an accuracy of 83.7% for the truthful and 77.5% for the deceptive subjects.

This paper reports data collected during the Validation of the Polygraph Quadri-Zone Comparison Technique (Matte & Reuss 1989).

Procedure

All polygraph specific-issue tests conducted with the Quadri-Zone Comparison Technique at the Buffalo Police Department from January 1985 through December 1987 were reviewed. There were 113 cases of which 32 were later solved by confessions, investigations, convictions, and combinations of these methods. In addition, all specific-issue tests conducted with the Quadri-Zone Comparison Technique at Matte Polygraph Service, Inc., from January 1986 through April 1987 were reviewed. There were 145 cases of which 90 were subsequently solved by one or more of the previously mentioned methods. Thus, 122 of the total of 258 available cases (47%) were subsequently solved, providing a base of confirmed cases for study. (For more detail regarding ground truth data and explanation of Quadri-Zone Technique, see Validation Study of Quadri-Zone Technique in Polygraph (1989), 18(4).

The Polygraphists' decisions at the end of these 122 cases were: 62 deception indicated (DI), 53 no deception indicated (NDI), and 7 inconclusive (Inc). Of the 7 inconclusive cases, 5 were solved as innocent and 2 as guilty. The subject population of the 122 cases included 64 men and 58 women. There were 84 while persons, 37 black persons, and one American Indian. The age range was 16 to 60 and averaged 32. The educational level ranged from 8 years to 16 years and averaged 13 years. The average education level for the guilty was 13 years and the innocent 12 years. There were 85 crimes against property, 37 against persons.

The three polygraphists were James Allan Matte, Ph.D., Detective Thomas E. Armitage, Polygraphist, Buffalo Police Department, and Detective Ciro F. LaCorte, Polygraphist, Amherst Police Department. The polygraph instrument used at Matte Polygraph Service in the years 1986-1987 was a Stoelting electronic four-pen, double pneumograph, Ultra-Scribe, and the polygraph instrument used at the Buffalo Police Department in the years 1985-1987 was a Stoelting electronic four-pen, double pneumograph Polyscribe.

The aforementioned 122 verified cases yielded a total of 311 polygraph charts. All of these polygraph charts contained both an upper pneumograph tracing for thoracic breathing patterns and a lower pneumograph tracing for abdominal breathing patterns. These polygraph charts also contained a galvanic skin response tracing obtained from finger electrodes, and a cardiograph tracing obtained from a blood pressure cuff normally wrapped around the left or right bicep. All of these tracings were electronically enhanced inasmuch as both of the aforementioned Ultrascribe and Polyscribe polygraph instruments are fully electronic. In this study all the thoracic patterns were on the upper channel and all the abdominal patterns were on the lower channel.

The polygraph charts in this study were examined to determine which of the two pneumograph tracings, thoracic or abdominal, was the most productive on the basis of the clarity and purity of its tracing, and adequacy of its amplitude. The key question was whether there was a significant difference in the pneumograph tracings for the persons tested. The possibilities were that the tracings might have been equal, or the upper pneumo or the lower pneumo showed a more significant physiological response. We have also asked the question whether there were any sex differences in the pneumo tracings. A further question was whether there were any differences for the innocent versus the guilty responses in the pneumo tracing, with a further breakdown by sex.

All of the polygraph charts in this study were also examined to determine which of the three parameters, Pneumo, GSR, or Cardio, was the most productive tracing on the basis of the sum of the verified scores attained in each tracing. Therefore the tracing which accumulated the highest score consistent with ground truth was deemed the most productive, followed by the next highest score consistent with ground truth and so forth. IT should be noted that the Quadri-Zone Comparison Technique employs a seven position scale (+3, +2, +1, 0, -1, -2, -3) with clearly defined rules for the assignment of each score (Matte, 1978, 1980, 1989). The scores are obtained from a comparison between each control question and its neighboring relevant question; a negative score for the relevant greater than the control, positive for the control greater than the relevant, and zero if the arousals are about even, with the exception that when there is equal but strong arousal in either the pneumo or cardio tracing, a -1 score is assigned to this question pair. We also asked the question whether there were any differences in the most productive tracing for male/female and guilty/innocent subjects.

Results

The most productive tracing overall tends to be the Pneumo (43%), to the Cardio (32%), and the GSR (24%)(Table 2A). They were of equal physiological responses in only 2% of the cases. One might think they should be randomly distributed equally or of equal response. According to the data, we reject the hypothesis that they are randomly distributed equally ($p = .0376$)(Table 3,2A2) and we strongly reject the hypothesis that they are of equal response, ($p = .000001$)(Table 3, 2A1). This was also equally rejected for both male and female subjects. According to the Chi Square - Goodness of Fit test on the data, we also reject the concept that there is an equal

chance distribution of response in the three tracings for males, ($p = .0048$)(Table 3,2A2). The data indicates that there is a strong response on the Pneumo and Cardio for males with a significantly lower response in the GSR. The female distribution is more equal for the three tracings and we fail to reject the hypothesis that there are significant differences ($p = .33$)(Table 3,2A2). Since there was no significant difference in the responses for females, we could not define a dominant physiological tracing for the females.

When the males were compared for the Innocent cases versus the Guilty cases, the most productive overall tracing for the Innocent cases was quite predominantly the pneumo (67% versus the Guilty cases which was the Cardio (46%) followed closely by the Pneumo for the Guilty (37%). The GSR was lowest for both the Innocent (11%) and Guilty cases (15%)(Table 3B). Clearly the pneumo tracing was the more significant overall physiological tracing for the Innocent male (67%) but dropping to only 37% for the guilty males. This shift was caused by the increased productivity of the Cardio tracing for the Guilty (46%) versus the Innocent (22%)(Table 2E).

When the females were compared for the Innocent versus the Guilty cases, the most productive overall tracing for the Innocent cases was predominantly the GSR (43%) followed by the Pneumo (38%) and the Cardio (19%). The most productive overall tracing for the Guilty cases was the Pneumo (44%) followed by the Cardio (39%) and the GSR (17%). Clearly the GSR was the more significant physiological tracing for the Innocent females (43%) versus the Guilty (17%)(Table 4B). For the females the Cardio shifted from being the least productive in the Innocent (18%) to the second most productive in the Guilty (39%)(Table 2F).

The most productive overall tracing for all of the Innocent cases is the Pneumo (47%) followed by the GSR (33%) and the Cardio (19%)(Table 2B).

The most productive overall tracing for all of the Guilty cases is the Cardio (44%) followed by the Pneumo (39%) and the GSR (16%)(Table 2C).

The overall distribution is significantly different showing that the Pneumo tracing is the significant racing, with Cardio a close second and GSR the least commonly dominant response. There is also a significant sex difference in the response with the males showing stronger Pneumo and Cardio curves versus the females with a more likely balance among the physiological tracings.

For the pneumo tracings which produced particularly diverse results, the Lower (abdominal) tracing was most productive for 52% of the cases, the Upper (thoracic) 16%, and they were the same in 33% of the cases. According to the Goodness of Fit test (Table 3) using the Chi Square, assuming there should be a random chance of either to predominate or they should be equal, we reject the hypothesis that there are no significant difference ($p = <.05$ level)(Table 3, 1A1). There is a strong indication that there is a dominant trace overall (the lower pneumo), with the upper being significant in the least number of cases.

There are major sex differences in the pneumo tracings (Table 1A). The Upper is more significant in 33% of the females, but not in the males. The Lower is significant in 75% of the males, but in only 26% of the females. The Upper and Lower are about the same for 41% of the females, but only 25% of the males. This difference was found to be significant ($p = <.0000011$)(Table 3,1A2). There is a major difference in the breathing response of males and females. For the females 74% produce an Upper breathing response, or produce an equal Upper and Lower response. Only 26% of the females show a lower dominance in breathing response. For the males 100% favor a Lower response or an equal Upper and Lower breathing response. In this study no males showed an upper dominance in breathing response. This sex difference was found to be significant ($p = <.0000015$)(Table 3,1A2). This indicates that males show a definite tendency to show stronger Lower breathing responses. We fail to reject the hypothesis that there is a significant difference for females ($p = <.339$)(Table 3,1A2). This indicates that there is a stronger probability of an equal chance of Upper, Lower, or Equal dominance in the pneumo tracing for females.

When the males were compared for the Innocent cases versus the Guilty cases, the most productive pneumo, the lower was predominant for a greater percentage of Innocent cases (83%)(Table 1B) compared to Guilty cases (72%)(Table 1C). When the females were compared for the Innocent cases versus the Guilty cases, 75% of the Innocent cases showed an Upper breathing response (40% of all the cases) or an equal Upper and Lower breathing response (35% of the cases)(Table 1B). However, for the Guilty female cases there was a shift away from the Upper Pneumo toward the equalization of Upper and Lower Pneumo (56%)(Table 1C).

The most productive pneumograph tracing for all of the Innocent cases is the Lower (Abdominal) (43%) versus equal productivity (Upper-Lower) (29%) and Upper (Thoracic) (28%)(Table 1D). The most productive pneumo tracing for all of the Guilty cases is the Lower (39%) versus equal productivity (Upper-Lower) (36%) and Upper (25%)(Table 1D).

Discussion

In comparing the results of our field research study with aforementioned previous research on the effectiveness of the Pneumo, GSR and Cardio polygraph components, it becomes apparent that the ineffectiveness of the pneumograph in some of these studies (Barland 1986, Thackray 1968, Cutrow 1972) was most likely due to the positioning of the single pneumograph component on the least productive breathing area. The results of this study show that whenever possible a double pneumograph that records thoracic and abdominal breathing patterns should be used in all polygraph examinations. If for any reason a polygraphist or research scientist is limited to one pneumograph component, then that single pneumograph component should be positioned over the breast (thoracic area) of female subjects and over the stomach (abdominal area) of male subjects. However, because there are exceptions to that rule, a trial chart should be conducted with the pneumograph component placed first in the recommended area, than in the opposite area for confirmation.

In our study all of the cases contained verified charts and the accuracy and utility of each polygraph tracing was based on scores obtained from a 7-position scale with an increasing threshold rather than a 3-position scale with no threshold (Ryan). Further, the Quadri-Zone Comparison technique, a single-issue test which employs no secondary relevant question was used in this study. We believe that the 7-position scale offers a more precise and refined evaluation of the degree of arousal than the 3-position scale, and that the dampening effect that secondary relevant questions may have on primary relevant and control questions may cause a failure of those affected questions in producing to their optimum capacity, hence reducing the accuracy of its evaluation. This difference in technique and in scoring may also account for some of the results being different from those produced by other studies.

We note that mock crime studies of the GSR is the most effective overall parameter (Raskin et al., Thackray et al., Cutrow et al.), but in the field studies the Pneumograph is the most effective overall parameter (Jayne, Slowik & Buckley, Matte & Reuss) and the GSR is often the least effective parameter (Jayne, Matte & Reuss). In Ryan's study the GSR was most effective in identifying the Guilty, but respiration was the most effective in identifying the innocent. When Inconclusives are omitted from Ryan's data, the respiration parameter was found to be significantly more useful than the GSR and Cardio for both the truthful and deceptive subjects.

Interestingly, in our study the Pneumo was the most productive parameter (43%), followed by Cardio (32%), and GSR (24%). However, when males were compared for the Innocent versus Guilty cases, the most productive tracing for the Innocent cases was predominantly the Pneumo (67%) versus the Guilty cases where it was the Cardio (46%) followed closely by the Pneumo (37%). The GSR was lowest for both the Innocent (11%) and Guilty (15%). This shift from the Pneumo for the Innocent to the Cardio for the Guilty males is the results of increased productivity of the Cardio tracing for the Guilty (46%) versus the Innocent (22%). When the females were compared for the Innocent versus Guilty cases, the productivity of the GSR shifted from being the most productive tracing at 43%, then pneumo at 38%, and cardio at 18% for the Innocent to the least productive tracing, GSR at 17%, pneumo at 44%, and cardio at 39% for the Guilty. The Cardio shifted from being the least productive tracing (18%) with the female Innocent to the second most productive tracing (39%) for the Guilty.

We believe that the difference in psychodynamics between subjects in mock paradigms (Laboratory studies) and field studies (real-life cases) explain the significant differences seen in the reported research for these different types of studies. The key factors for the psychodynamic differences are felt to be the "Fear of Detection" by the Guilty and the "Fear of Error" by the Innocent.

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- TABLES -

TABLE 1

MPP MOST PRODUCTIVE PNEUMOGRAPH

TABLE 1A MPP-A MOST PRODUCTIVE PNEUMOGRAPH-OVERALL
Compares the pneumograph tracings for the most productive among the cases on this study.

	PNEUMOGRAPH			
	UPPER	LOWER	SAME	TOTALS
MALES	0 0%	48 75%	16 25%	64 52%
FEMALES	19 33%	15 26%	24 41%	58 48%
TOTALS	19 16%	63 52%	40 33%	122 100%

TABLE 1B MPP-B MOST PRODUCTIVE PNEUMOGRAPH - INNOCENT CASES

Compares the pneumograph tracings for the most productive among the Innocent Cases on this study.

	PNEUMOGRAPH			
	UPPER	LOWER	SAME	TOTALS
MALES	0 0%	15 83%	3 17%	18 31%
FEMALES	16 40%	10 25%	14 35%	40 69%
TOTALS	16 28%	25 43%	17 29%	58 100%

TABLE 1C MPP-C MOST PRODUCTIVE PNEUMOGRAPH-GUILTY CASES

Compares the pneumograph tracings for the most productive among the Guilty cases on this study.

	PNEUMOGRAPH			
	UPPER	LOWER	SAME	TOTALS
MALES	0	33	13	46
	0%	72%	28%	72%
FEMALES	3	5	10	18
	17%	28%	56%	28%
TOTALS	3	38	23	64
	5%	59%	36%	100%

TABLE 1D MPP-D MOST PRODUCTIVE PNEUMOGRAPH-OVERALL-2

Compares the pneumograph tracings for the most productive among the cases separated by Innocent or Guilty on this study.

		PNEUMOGRAPH			
		UPPER	LOWER	SAME	TOTALS
INNOCENT	M	0	15	3	18
	F	16	10	14	40
	TOTAL	16	25	17	58
		28%	43%	29%	48%
GUILTY	M	0	33	13	46
	F	3	5	10	18
	TOTAL	3	38	23	64
		5%	59%	36%	52%
TOTALS		19	63	40	122
		16%	52%	33%	100%

TABLE 1E MPP-E MOST PRODUCTIVE PNEUMOGRAPH-MALES CASES

Compares the pneumograph tracings for the most productive among the male cases on this study.

	PNEUMOGRAPH			
	UPPER	LOWER	SAME	TOTALS
INNOCENT	0 0%	15 83%	3 17%	18 28%
GUILTY	0 0%	33 72%	14 28%	46 72%
TOTALS	0 0%	48 75%	16 25%	64 100%

TABLE 1F MPP-F MOST PRODUCTIVE PNEUMOGRAPH-FEMALE CASES

Compares the pneumograph tracings for the most productive among the female cases on this study.

	PNEUMOGRAPH			
	UPPER	LOWER	SAME	TOTALS
INNOCENT	16 40%	10 25%	14 35%	40 69%
GUILTY	3 17%	5 28%	10 56%	18 31%
TOTALS	19 33%	15 26%	24 41%	58 100%

TABLE 2 MPO MOST PRODUCTIVE OVERALL TRACE

TABLE 2A MPO-A MOST PRODUCTIVE TRACE - OVERALL
Compare the physiological tracings for the most productive among the cases on this study.

MOST PRODUCTIVE TRACINGS

	CARDIO	PNEUMO	GSR	EQUAL	TOTALS
MALES	25	29	9	1	64
	39%	45%	14%	2%	52%
FEMALES	14	23	20	1	58
	24%	40%	34%	2%	48%
TOTALS	39	52	29	2	122
	32%	43%	24%	2%	100%

TABLE 2B MPO-B MOST PRODUCTIVE TRACE - INNOCENT CASES
Compares the physiological tracings for the most productive among the Innocent cases on this study.

MOST PRODUCTIVE TRACINGS

	CARDIO	PNEUMO	GSR	EQUAL	TOTALS
MALES	4	12	2	0	18
	22%	67%	11%	0%	31%
FEMALES	7	15	17	1	40
	18%	38%	43%	2%	69%
TOTALS	11	27	19	1	58
	19%	47%	33%	2%	100%

TABLE 2C MPO-C MOST PRODUCTIVE TRACE - GUILTY CASES
Compares the physiological tracings for the most productive among the Guilty cases on this study.

	MOST PRODUCTIVE TRACINGS				
	CARDIO	PNEUMO	GSR	EQUAL	TOTALS
MALES	21	17	7	1	46
	46%	37%	15%	2%	72%
FEMALES	7	8	3	0	18
	39%	44%	17%	0%	28%
TOTALS	28	25	10	1	64
	44%	39%	16%	2%	100%

TABLE 2D MPO-D MOST PRODUCTIVE TRACE - OVERALL-2
Compare the physiological tracings for the most productive among the cases separated by Innocent and Guilty on this study.

		MOST PRODUCTIVE TRACINGS				
		CARDIO	PNEUMO	GSR	EQUAL	TOTALS
INNOCENT	F	4	12	2	0	18
	M	7	15	17	1	40
TOTALS		11	27	19	1	58
		19%	47%	33%	2%	48%
GUILTY	F	21	17	7	1	46
	M	7	8	3	0	18
TOTALS		28	25	10	1	64
		44%	39%	16%	2%	52%
TOTALS		39	52	29	2	122
		32%	43%	24%	2%	100%

TABLE 2E - MPO-E MOST PRODUCTIVE TRACE - MALES CASES
Compares the physiological tracings for the most productive among the male cases on this study.

MOST PRODUCTIVE TRACING

	CARDIO	PNEUMO	GSR	EQUAL	TOTALS
INNOCENT	4	12	2	0	18
	22%	67%	11%	0%	28%
GUILTY	21	17	7	1	46
	46%	37%	15%	2%	72%
TOTALS	25	29	9	1	64
	39%	45%	14%	2%	100%

TABLE 2F MPO-F MOST PRODUCTIVE TRACE - FEMALE CASES
Compares the physiological tracings for the most productive among the Female cases on this study.

MOST PRODUCTIVE TRACINGS

	CARDIO	PNEUMO	GSR	EQUAL	TOTALS
INNOCENT	7	15	17	1	40
	18%	38%	43%	2%	69%
GUILTY	7	8	3	0	18
	39%	44%	17%	0%	31%
TOTALS	14	23	20	1	58
	24%	40%	34%	2%	100%

TABLE 3 GOF-2 GOODNESS OF FIT - CHI SQUARE TESTS

To test whether there are any significant differences in the data for Overall Most Productive Tracing and Most Productive Pneumograph Tracing for Males and Females Based on data for Table 1 A-F - MOST PRODUCTIVE PNEUMOGRAPH and Table 2 A-F MOST PRODUCTIVE OVERALL

TABLE 1A MMP-A MOST PRODUCTIVE PNEUMOGRAPH - OVERALL

1. Assuming They Should be the Same:

DF = 0 DF = 1 M 36 F 19.9
Chi-Sq= 55.11 Chi-Sq (M&F) = 55.9
P = .0000013 P = .0000011

2. Assuming There Should Be Equal Random Distribution

Table 1A TOTALS - MOST PRODUCTIVE PNEUMO

	UPPER	LOWER	SAME
DF = 2	11.8	11.8	.024
Chi-Sq = 23.63			
P = .0000073			

Table 1A MALES - MOST PRODUCTIVE PNEUMO

	UPPER	LOWER	SAME
DF = 2	21.	34.7	1.19
Chi-Sq = 56.9			
P = .0000015			

Table 1A FEMALES - MOST PRODUCTIVE PNEUMO

	UPPER	LOWER	SAME
DF = 2	0	.84	1.3
Chi-Sq = 2.16			
P = .339			

TABLE 1B MMP-B MOST PRODUCTIVE PNEUMOGRAPH - INNOCENT

1. Assuming they Should Be the Same:

DF = 0 DF = 0 DF = 0
Chi-Sq = 28.98 Chi-Sq (m) = 12.5 Chi-Sq (F) = 16.9
P = .00000023 P = .0000000238 P = .0000

2. Assuming There Should Be Equal Random Distribution

Table 1B TOTALS - MOST PRODUCTIVE PNEUMO OVERALL - INNOCENT

	UPPER	LOWER	SAME
DF = 2	.47	1.89	.21
Chi-Sq = 2.58			
P = .275			

Table 1B - MALES - MOST PRODUCTIVE PNEUMO - INNOCENT

	UPPER	LOWER	SAME
DF = 2	6.	13.5	1.5
Chi-Sq = 21.			
P = .000027			

Table 1B - FEMALES - MOST PRODUCTIVE PNEUMO - INNOCENT

	UPPER	LOWER	SAME
DF = 2	.69	.69	7.6
Chi-Sq - 1.46			
P = .48			

TABLE 1C - MMP-C MOST PRODUCTIVE PNEUMOGRAPH - GUILTY

1. Assuming They Should Be the Same:

DF = 0	DF = 0	DF = 0
Chi-Sq - 26.3	Chi-Sq (M) = 23.6	Chi-Sq (F) = 3.56
P = .00000012	P = .00000035	P = .0000

2. Assuming There Should Be Equal Random Distribution

Table 1C TOTALS - MOST PRODUCTIVE PNEUMO OVERALL - GUILTY

	UPPER	LOWER	SAME
DF = 2	2.3	.76	5.76
Chi-Sq = 8.86			
P = .0119			

Table 1C MALES - MOST PRODUCTIVE PNEUMO - GUILTY

	UPPER	LOWER	SAME
DF = 2	2.4	.27	4.27
Chi-Sq = 5.93			
P = .031			

Table 1C FEMALES - MOST PRODUCTIVE PNEUMO - GUILTY

	UPPER	LOWER	SAME
DF = 2	.17	.67	1.5
Chi-Sq = 2.33			
P = .311			

TABLE 1D MMP-D MOST PRODUCTIVE PNEUMOGRAPH - OVERALL

1. Assuming They Should Be the Same:

DF = 0
Chi-Sq = 55.11
P = .0000013

2. Assuming There Should be Equal Random Distribution

Table 1D TOTALS - MOST PRODUCTIVE PNEUMO OVERALL

	UPPER	LOWER	SAME
DF = 2	11.8	11.8	.024
Chi-Sq = 23.63			
P = .0000073			

Table 1D MOST PRODUCTIVE PNEUMO - INNOCENT

	UPPER	LOWER	SAME
DF = 2	.47	1.89	.21
Chi-Sq = 2.58			
P = .275			

Table 1D MOST PRODUCTIVE PNEUMO - GUILTY

	UPPER	LOWER	SAME
DF = 2	2.3	.76	5.76
Chi-Sq = 8.86			
P = .0119			

TABLE 1E - MMP-E MOST PRODUCTIVE PNEUMOGRAPH - MALE CASES

1 Assuming They Should Be the Same:

DF = 0	DF = 0	DF = 0
Chi-Sq = 36.0	Chi-Sq (I)= 12.5	Chi-Sq (G) = 23.7
P = -.000000715	P = .00000023	P = .00000035

2. Assuming There Should Be Equal Random Distribution

Table 1E TOTALS - MOST PRODUCTIVE PNEUMO OVERALL - MALES

	UPPER	LOWER	SAME
DF = 2	21.0	6.9	3.0
Chi-Sq = 30.8			
P = .00000024			

Table 1E - MOST PRODUCTIVE PNEUMO - INNOCENT

	UPPER	LOWER	SAME
DF = 2	6.	13.5	1.5
Chi-Sq = 21.0			
P = .000027			

Table 1E - MOST PRODUCTIVE PNEUMO - GUILTY

	UPPER	LOWER	SAME
DF = 2	15.0	21.6	27.0
Chi-Sq = 36.9			
P = .00000041			

TABLE 1F MMP-F MOST PRODUCTIVE PNEUMOGRAPH - FEMALE CASES

1. Assuming They Should Be the Same:

DF = 0	DF = 0	DF = 0
Chi-Sq = 19.9	Chi-Sq (I) = 16.9	Chi-Sq (G) - 3.56
P = - .0000	P = .0000	P = .0000

2. Assuming There Should be Equal Random Distribution

Table 1F TOTALS - MOST PRODUCTIVE PNEUMO OVERALL - FEMALES

	UPPER	LOWER	SAME
DF = 2	.0	.84	1.3
Chi-Sq = 2.16			
P = .339			

Table 1F - MOST PRODUCTIVE PNEUMO - INNOCENT

	UPPER	LOWER	SAME
DF = 2	.69	.69	.077
Chi-Sq = 1.46			
P = .48			

Table 1F - MOST PRODUCTIVE PNEUMO - GUILTY

	UPPER	LOWER	SAME
DF = 2	1.5	.17	2.67
Chi-Sq = 4.33			
P = .115			

TABLE 2A MPO-A MOST PRODUCTIVE TRACE - OVERALL

1. Assuming They Should Be the Same - Equal Overall

DF = 0	DF = 1	M 62	F 56
Chi-Sq = 118	Chi-Sq 118		
P = .0000014	P = .0000009		

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2A TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.097	2.95	3.51
Chi-Sq = 6.56			
P = .0376			

Table 2A MALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.76	3.04	6.85
Chi-Sq = 10.67			
P = .0048			

Table 2A FEMALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	1.3	.84	.053
Chi-Sq = 2.21			
P = .33			

TABLE 2B MPO-B MOST PRODUCTIVE TRACE - INNOCENT CASES

1. Assuming They Should Be the Same - Equal Overall

DF = 0	DF = 0	DF = 0
Chi-Sq = 56	Chi-Sq (M) = 18	Chi-Sq (F) = 38
P = -.0000011	P = -.00000024	P = -.00000072

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2B TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	3.36	3.36	0.0
Chi-Sq = 6.74			
P = .034			

Table 2B MALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.67	6.0	2.67
Chi-Sq = 9.33			
P = .0094			

Table 2B FEMALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.76	.31	1.2
Chi-Sq = 4.31			
P = .116			

TABLE 2C - MPO-C MOST PRODUCTIVE TRACE - GUILTY CASES

1. Assuming They Should Be the Same - Equal Overall

DF = 0	DF = 0	DF = 0
Chi-Sq = 62	Chi-Sq (M) = 44	Chi-Sq (F) = 18
P = .00000017	P = -.00000011	P = -.00000024

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2C TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.3	.76	5.76
Chi-Sq = 8.86			
P = .0119			

Table 2C MALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.4	.27	4.27
Chi-Sq = 6.93			
P = .031			

Table 2C FEMALES - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.17	.67	1.5
Chi-Sq = 2.33			
P = .311			

TABLE 2D MPO-D MOST PRODUCTIVE TRACE - OVERALL -2

1. Assuming They Should Be the Same - Equal Overall

DF = 0
Chi-Sq - 118
P = .0000014

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2D TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.097	2.95	3.51
Chi-Sq = 6.56			
P = .0376			

Table 2D INNOCENT - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	3.36	3.36	0.0
Chi-Sq = 6.74			
P = .034			

Table 2D GUILTY - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.3	.76	5.76
Chi-Sq = 8.86			
P = .0119			

TABLE 2E MPO-E MOST PRODUCTIVE TRACE - MALES CASES

1. Assuming They Should Be the Same - Equal Overall

DF = 0	DF = 0	DF = 0
Chi-Sq = 62	Chi-Sq (I) = 18	Chi-Sq (G) = 44
P = .00000018	P = .00000024	P = .00000012

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2E TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.76	3.04	6.85
Chi-Sq = 10.7			
P = .0048			

Table 2E INNOCENT - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.67	6.0	2.67
Chi-Sq = 9.33			
P = .0094			

Table 2E GUILTY - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.4	.27	4.2
Chi-Sq = 6.93			
P = .031			

TABLE 2F MPO-F MOST PRODUCTIVE TRACE - FEMALE CASES

1. Assuming They Should Be the Same - Female Cases

DF = 0	DF = 0	DF = 0
Chi-Sq = 56	Chi-Sq (I) = 38	Chi-SQ (G) = 18
P = -.0000011	P = .00000071	P = .00000024

2. Assuming There Should Be Equal Random Distribution - Overall

Table 2F TOTALS - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	1.3	.84	5.26
Chi-Sq = 2.21			
P = .331			

Table 2F INNOCENT - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	2.77	.30	1.23
Chi-Sq = 4.31			
P = .116			

Table 2F GUILTY - MOST PRODUCTIVE TRACE

	CARDIO	PNEUMO	GSR
DF = 2	.17	.67	1.5
Chi-Sq = 2.33			
P = .311			