The Physiological Differentiation between Fear and Anger in Humans

ALBERT F. AX, Ph.D.

SIMULTANEOUS multiple recording of several physiological reactions during emotional changes may serve several purposes. The primary purpose is to add to our understanding of the precise nature of the total emotional reaction, which has not been adequately studied. From the psychological point of view, the details of the physiological state constitute an essential part of the conditions existing at the time of observation.

Multiple recording contributes more than the mere addition of variables for observation. The quantitative patterns of these differentially influenced processes (such as blood pressure, heart rate, sweating, skin temperature) provide a qualitative description of the emotional state at the physiological level and may be diagnostic of the type of emotional reaction. This characteristic of being differentially influenced by varying emotional states was an essential consideration in selecting which variables to record. Other criteria for selecting the variables were that they be available for continuous recording and that recording them would not seriously disturb the subject.

The multiple-variable approach for studying physiological states may provide answers to three different questions: (1) Can individuals be classified in terms of their physiological reaction syndromes, which are paradigmed by the psychosomatic diseases? (2) Can the physiological reactions serve as an emotional or motivational indicator during psychological observation? This is a classical use of physiological reactions made by psychologists. (3) The third approach seeks for patterns of physiological reaction which may be diagnostic of the primary emotional states. It seeks to examine, for example, Cannon's hypothesis that fear and anger are essentially similar physiological reactions.

This paper reports a study of the latter type of polygraph research: that is, the physiological differentiation of two emotional states. Fear and anger were selected for study as being the two emotional states most often described as being identical physiological states. Although Cannon's theory that "fight and flight" excitement states have similar visceral patterns has been demonstrated to be generally true, there has always existed the possibility that a closer inspection of the physiological reaction patterns might reveal a differentiation or subtyping of the excitement states.

There have been hints deriving from both theoretical and experimental sources that question the hypothesis of the undifferentiated physiological state. Magda Arnold,[1] arguing from both neurological evidence and a reconsideration of published experimental data, concluded that fear is a strong arousal state of the sympathetic branch of the autonomic nervous system, whereas anger is a strong arousal state of both the sympathetic and parasympathetic branches of the autonomic nervous system. Wolf and Wolff have described increases in motility, secretion, and vascular dilatation of the viscera associated with anger or resentment and decreases in these functions during anxiety and depression. Mittleman and

---

From the Department of Psychiatry, University of Washington School of Medicine, Seattle 5, Washington.

Support for this study was provided by the Laboratory of Social Relations at Harvard University; the Boston Psychopathic Hospital; and the Department of Psychiatry, University of Washington School of Medicine. Dr. and Mrs. Joseph Schachter and Andrew Jensen cooperated in this research.

Received for publication July 29, 1952.

Wolff, in a study of finger temperature changes during psychoanalytical therapy, reported that decreases in temperature were associated with periods of anxiety and discussions of unpleasant topics, while during sexual excitement there were increases in finger temperature.

None of these studies, however, clearly demonstrated that these reported differences in physiological response might not be due either to different intensities of arousal or merely to the unique response patterns of a single individual. Accordingly, for this study it was planned to select an adequate sample and to record simultaneously with the emotional arousal a number of physiological reactions which could produce "patterns" of response.

Procedure

The variables recorded are shown in Fig. 1. The Grass eight-channel electroencephalograph was used as the main recorder and amplifier. Since the Grass has only *A. C.* amplifiers, modulated *A. C.* envelopes were used for all continuous variables. The transducers can be briefly described. (1) The electrocardiogram was recorded directly from ear and leg leads. (2) The ballistocardiogram, as an index of stroke volume, was produced by a crystal phono pickup imbedded in a wooden block lying across the subject's ankles. A small lead weight on the end of the stylus converts the pickup into an efficient accelerometer which responds to the ballistic reaction of the body to ejection of blood from the heart. (3) Respiration was recorded from thorax and abdominal pneumograph tubes activating an inductance tambour. (4 and 5) Face and finger skin temperatures were detected by V-611 Western Electric thermistors in an *A. C.* bridge using the electroencephalograph for recording the imbalance. (6) The skin conductance, as the index of sweating of the volar surfaces of two fingers of one hand, was also measured by a bridge using 60-cycle *A. C.* (7) Finally, at the bottom of the chart is the integrated muscle potential index from the frontalis muscle picked up by sponge electrodes and integrated and recorded as a modulated 60-cycle envelope. Systolic and diastolic blood pressures were taken every minute by a nurse. The room temperature was held constant at 23° C. ± 0.1° C.

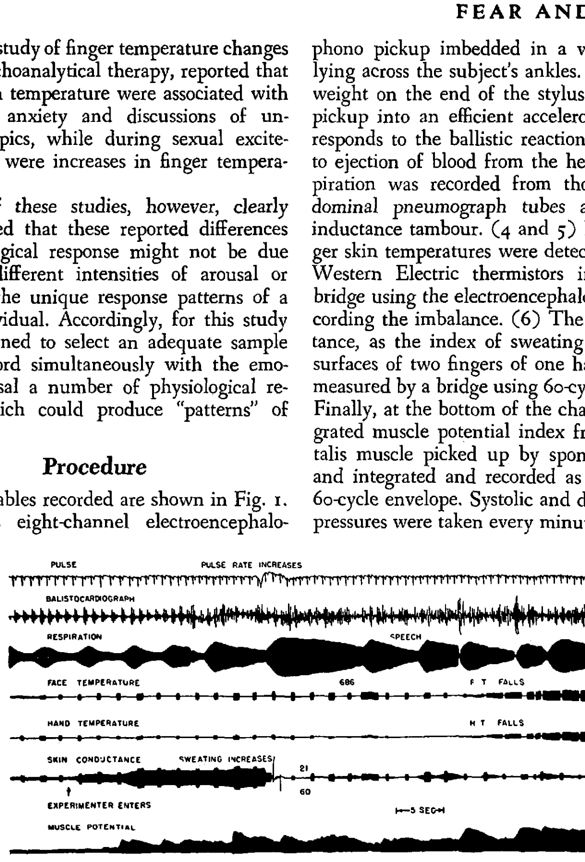

Fig. 1. The variables recorded in this study. The Grass eight-channel electroencephalograph was used as the main recorder and amplifier. Since the Grass has only *A. C.* amplifiers, modulated *A. C.* envelopes were used for all continuous variables.

The subject reclined in the testing room on a rigid table covered by a hair mattress. The nurse and experimenter were also in this room. The polygraph and operator were in an adjacent room.

The subjects were recruited through newspaper advertisements and a state employment agency. The only criteria for inclusion were that they must be free from any illness and within the age limits of 21 and 55 years. The average age was 27 years; 22 were men and 21 women. They were paid $3.00 for 2 hours. Only those whose blood pressure did not exceed 140/90 after 20 minutes rest were included.

The subjects were told that this was a study of the physiological differences between people with hypertension and those without hypertension, that their only task was to relax on the bed and listen to their preferred music for about an hour. A rest period of 25 minutes preceded the stimulus periods. The stimulation periods of fear and anger were alternated so that 22 subjects received the fear stimulation first and 21 subjects received the anger stimulation first.

The fear stimulus consisted of a gradually increasing intermittent shock stimulus to the little finger which never reached an intensity sufficient to cause pain. When the subject reported the sensation, the experimenter expressed surprise, checked the wiring, pressed a key which caused sparks to jump near the subject, then exclaimed with alarm that this was a dangerous high-voltage short circuit. The experimenter created an atmosphere of alarm and confusion. After five minutes from the time the subject reported the shock, the experimenter removed the shock wire, assuring the subject that all danger was past, that the short circuit had been found and repaired. A ten- to fifteen-minute recovery period with music separated the fear and anger stimuli.

The polygraph operator was the key figure for the anger situation. He was described to the subject as not the regular operator but one who had been fired for incompetence and arrogance, but due to the sickness of the regular operator he had to be employed for that day. Thus he was labeled as a suitable target for hostility by the subject.

At the beginning of the anger stimulus, the operator entered the room stating he must check the wiring because some of the calibrations might be off. The experimenter objected but agreed to go into the other room and operate the polygraph. The operator shut off the music, criticized the nurse, and told the subject sarcastically that it would have helped if he had been on time. He checked the electrodes, roughly adjusted the subject, and criticized him for moving, noncooperation, and other behavior. After five minutes of abuse, the operator left and the experimenter returned, apologizing for this rude behavior. The experimenter reassured the subject and urged him to relax once more. After ten minutes the experimenter interviewed the subject for a five-minute period, questioning his memory and feelings for the first interruption; following another ten-minute rest period, the experimenter questioned him about the second interruption.

Remarks made by subjects either just after the stress stimulus or during the interviews illustrate their feeling states. Just after the operator left the room following the "anger" stimulus, one female subject said, "Well! It's easy to see he is not an educated man." A male subject said, "Say, what goes on here? I was just about to punch that character on the nose." Examples of fear reactions were also clearly genuine. One woman kept pleading, "Please take the wires off. Oh! Please help me." Another said during the interview that she had prayed to be spared during the fear episode. A man said, "Well, everybody has to go sometime. I thought this might be my time."

Some subjects used rather far-fetched rationalizations to limit or prevent fear. One man with great assurance said, "I wasn't really worried because I knew these wires were much too small to be dangerous." One subject did not report the shock for several minutes. The experimenter noticed an involuntary twitching and asked about it. The subject said, "Oh, I thought that was just part of the experiment."

The records for 6 subjects were not included in this study because it was immediately decided, purely on the basis of the interview and observation before seeing the polygraph data, that these subjects did not become either sufficiently angry or frightened to justify comparison.

Analysis of Data

For all variables the maximum rises and falls during the stimulus period and the following two minutes (a total of seven minutes) were recorded as deviations from the resting level just prior to the stimulus period. Systolic and diastolic *blood pressures* recorded every minute were scored in millimeters of mercury. The *heart rate* was averaged for a six-second interval in selecting the maximum and minimum points. The *ballistocardiograph* score was the average voltage for approximately ten beats, covering exactly either two or three complete respirations.

Respiration was scored for changes in rate, amplitude, and inspiration/respiration ratio. Five consecutive breaths whose volume was judged to be maximum were selected for measurement. The I/R ratio and amplitude showed no significant difference for fear and anger. An index of volume, composed of the product of rate times amplitude, showed a significant difference which, however, was less significant than rate alone. Hence, rate was chosen as the variable to represent respiration.

Both *face temperature and hand temperature* were expressed in log units with the zero of the scale at 15° C., which is approximately 1° C. below the wet bulb thermometer temperature for the conditions of the experiment. Thus, if the finger were covered with perspiration and blood flow were zero, the temperature on the log units scale would approximate zero.

The *sweating index* was the skin conductance, which is the reciprocal of the resistance component of the impedance. Two aspects of conductance were scored: (1) the skin conductance rise as the maximum increase in conductance above the resting level just prior to the experimental period; (2) the number of increments per unit time in skin conductance of at least 1 micromho, which must have increased at least one micromho in three seconds.

One score for *muscle tension* was the maximum change in muscle potential which was averaged over a fifteen-second interval. The second muscle tension score was the average number of potential peaks per unit time. A peak was defined as an increment which doubled its size within three seconds.

Results

In Table 1 are tabulated the means, standard deviations, differences of means for anger and fear, the t of the differences, and the null probabilities for the fourteen variables. In Fig. 2, these means are graphed in standard

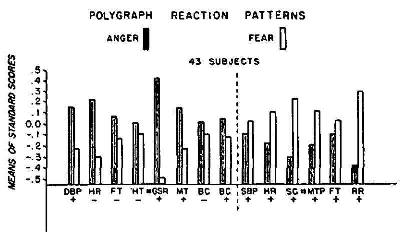

Fig. 2. The polygraph reactions, in standard score units, to the two stress situations called "anger" and "fear."

score units. The black bars represent the changes during the anger stimulus, and the white bars the changes during the fear stimulus. The + signs indicate increases in the variable, and the − signs decreases. Seven of the variables show significant differences between anger and fear. Four of the variables —diastolic blood pressure rises ($DBP+$), heart rate falls ($HR-$), number of galvanic skin responses ($\#GSR$), and muscle tension increases ($MT+$)—have greater average reactions for anger. Three variables—skin conductance increases ($SC+$), number of muscle tension peaks ($\#MTP$), and respiration rate increases ($RR+$)—have greater average reactions for fear.

It is of value to combine and express quantitatively these differences between the reactions of anger and fear, and also to provide a means of testing the significance of the combined differences. The difference between fear and anger which we wished to describe was not an amplitude difference but only the qualitative difference, which would be revealed in the profile shape with all average amplitude

TABLE 1. CHARACTERISTICS OF THE RAW SCORES

		DBP+	*HR−*	*FT−*	*HT−*	*#GSR*	*MT+*	*BC−*	*BC+*	*SBP+*	*HR+*	*SC+*	*#MTP*	*FT+*	*RR+*
Means	A	17.83	6.02	.00498	.0497	11.56	4.35	22.6	173.2	19.19	25.79	9.41	10.45	.00294	2.31
	F	14.49	3.98	.00414	.0448	4.74	3.34	18.4	142.8	20.35	30.32	14.81	13.17	.00348	6.00
σ	A	9.33	3.72	.00390	.0320	7.84	3.12	38.9	178.5	8.58	14.19	8.88	7.88	.00382	3.99
	F	7.97	3.41	.00366	.0208	5.08	2.08	40.3	134.4	11.77	17.69	10.42	7.94	.00317	6.50
MA − MF		3.34	2.04	.000842	.00489	6.82	1.01	4.2	31.56	− 1.16	− 4.53	− 5.40	− 2.72	− .00054	− 3.69
	t	2.47	3.66	1.22	.841	5.60	2.54	.79	1.15	.68	1.59	5.2	2.19	.87	3.46
Prob	t	.02	< .01	> .10	> .10	< .01	.02	> .10	> .10	> .10	> .10	< .01	.04	> .10	< .01

differences eliminated. Although there was no significant average amplitude difference between the fear and anger profiles, this factor was completely eliminated by the following procedure, illustrated for 1 subject in Table 2.

TABLE 2. SAMPLE OF METHOD FOR COMPUTING THE PROFILE DIFFERENCE SCORES

	A>F				A<F				
Subject 1.	*DBP+*	*HR−*	*MT+*	*#GSR*	*SC+*	*RR+*	*#MTP*		
F	−.470	1.077	−.657	−.700	1.381	−.018	1.146	ΣF	1.759
A	−.696	2.962	−.955	.377	.685	−1.667	.399	ΣA	1.105
Fc	−.563	.984	−.750	−.793	1.288	−.111	1.053	F − A	.654
A − Fc	−.133	1.978	−.205	1.170	−.603	−1.556	−.654	M_{f-a}	.093
	$\Sigma_{a>f}$ 2.810		$M_{a>f}$ .702		$\Sigma_{a<f}$ −2.813		$M_{a<f}$ −.938	$M_{a>f} - M_{a<f}$ 1.640	

Standard scores based on the mean and standard deviation for both anger and fear combined were computed for these seven variables for the 43 subjects. The scores of each profile were then summed across the seven variables. The difference between these two sums (*F—A*) was obtained and divided by 7 to obtain the average difference in amplitude for this subject. This average difference was then subtracted from each score of the fear profile to produce the corrected fear profile (*Fc*). The average amplitude of this corrected fear profile was now identical to the average amplitude of the anger profile. In the next step, each of these corrected fear scores was subtracted from its corresponding anger score (*A—Fc*). The mean of the differences for the four variables whose average amplitude was greater for anger was obtained ($M_{a>f}$, which for Subject 1 is .702). Likewise, the mean of the differences for the three variables whose average amplitude was less for anger was obtained ($M_{a<f} = -.938$). This latter mean difference was subtracted from the former [.702 — (—.938)] to produce the *profile difference score* of 1.640, which is a sum composed of the differences (*A—F*) between those variables which are greater for anger plus the negative differences —(*A—F*) between those variables which are greater for fear.

It might appear more direct merely to have summed the seven absolute differences and called it a "profile shape difference score." The difficulty with such a score is that even by the null hypothesis of no average difference between the shapes of the two profiles, the sum would have a mean of finite value of unknown distribution. Obtaining its theoretical distribution is complicated by intercorrelation of the variables.

The more useful profile difference score obtained, as described above, by subtracting the mean ($F > A$) differences from the mean ($A > F$) differences produces a distribution with a theoretical mean of zero, assuming the null hypothesis of no difference in shape between the anger and fear profiles. The reason the theoretical mean of this distribution of *profile difference scores* is zero is because it is a sum of seven distributions, each of which has a theoretical mean of zero, each being a distribution of differences of standard scores whose means are zero.

The actual distribution of the *profile difference scores* deviated very significantly from the theoretical one derived from the null hypothesis. Forty-two of the forty-three scores were positive, whereas the null expectation is that approximately half would be positive and half negative. The mean of the distribution was 1.087 with a t of 10.24, which indicates that the null hypothesis may be rejected with a high degree of confidence.

Discussion

It could be argued that the assignment of variables to the anger-greater-than-fear category and to the fear-greater-than-anger category on the basis of their mean differences would, of necessity, produce positive profile difference scores. There are, however, two legitimate methods for assignment of variables to the category: (1) by an hypothesis independent of this data; and (2) by inclusion of only those variables which have differences sufficiently great to establish with confidence their correct category. Both methods were employed in this study. The data from the first 16 subjects were examined and found to have the pattern relationships described here for the total group. The hypothesis is not completely independent, however, because the original 16 subjects are included in the total. The second principle of including only those variables showing significant differences bears the burden of our thesis. The fact that 50 per cent of the variables show significant differences around the .99 level of confidence constitutes the evidence that there is a difference in physiological reaction pattern to the two stimulus conditions here labeled "anger" and "fear." The individual *profile difference score* is a quantitative measure of the difference in reaction made by the individual for the two stimulus situations. It might be considered an index of emotional differentiation expressed in the physiological reaction.

The differences found can hardly be due to amplitude differences of the two emotional states, since some reactions were greater for fear and others were greater for anger. The differences remained when the profiles were equated for amplitude.

Possible interference effects due to the sequence of one stimulus situation following the other were controlled by stimulating half of the group first to anger and half of the group first to fear.

There was no selection of subjects which could have corrupted the results, since the only subjects eliminated were those 6 deemed not to have been both angered and frightened purely on the basis of the interview and observation, without reference to the physiological reactions.

An argument with some relevance may be raised. Possibly the differences found are not the result of two different emotional reactions, but related somehow to differences in the procedure and behavior of the subject during the two stimulus situations. Possibly there was more talking or small movements during one stimulus period than during the other. The two procedures were made as similar as possible. Close scrutiny of the records and of the wire recordings reveals no such systematic difference.

The use of two aspects of one variable, such as maximum rise in skin conductance ($SC+$) and the number of rises in skin conductance ($\#GSR$), or the maximum change in muscle tension ($MT+$) and the number of peaks in muscle tension ($\#MTP$) might be questioned. If two aspects of one variable were merely reciprocals of each other, they would be equally discriminative of the two states, but the second would contribute no additional discrimination over the first. Product moment correlations between maximum rise in skin conductance and number of rises in skin conductance were $-.05$ for fear and $+.38$ for anger. Correlations of muscle tension change with number of muscle tension peaks were $+.07$ for fear and $+.16$ for anger, which indicates almost a complete lack of dependence between them. The $+.38$ correlation between maximum changes in skin conductance and number of rises in skin conductance during anger probably indicates a small tendency for those subjects with the larger sweating response to make these responses more frequently but only during anger. The complete lack of substantial negative correlation certainly removes any question of these two aspects being merely reciprocals of each other.

A rather surprising finding is the general lack of correlation between the variables. The intervariable correlations are found in Table 3. Very few approach significance, and those are quite small compared to the self-correlations for fear and anger, which average .53. This lack of correlation among the physiological reactions fits a general hypothesis underlying this study: that is, that there is marked uniqueness in physiological expression of emotion. Evidence which further supports this thesis is the significantly larger between-subjects variance (9.68), as compared with the within-subjects variance (4.00), which has an F ratio of 2.42, significant at the 99 per cent level of confidence. (It was determined that neither distribution differed significantly from normal.) This finding is in essential agreement with results reported by Lacey and by Malmo,[5, 6, 7, 8] in which various types of autonomic responses are described as being characteristic either of the individual or of a special diagnostic group. This well-established specificity of autonomic-response pattern in a sense highlights the present findings of uniformity of response, which is characteristic of a specific emotional state experienced by many different individuals. If the physiological response pattern which is diagnostic of a specific emotional state could be measured for each individual as a deviation from his characteristic response pattern, much greater accuracy of specific emotional diagnosis might be expected.

Another interesting finding was the consistently larger correlations (neglecting sign) between the variables for anger than for fear. The mean of the fear correlations was .090 and for anger .157, the difference being significant at the 96 per cent level of confidence, the t being 2.25 for 20 degrees of freedom. One might interpret this greater tendency for higher correlation of the physiological reactions during anger to indicate a greater organization or integration during anger than during fear. Such an interpretation might be examined in terms of the evolutionary theory of the struggle for survival. Possibly successful attack would usually require greater mobilization and organization of the individual's resources than would flight. The paralysis of extreme fear might exemplify almost complete lack of effective integration.

TABLE 3. Correlations for Anger and Fear for the Variables Which Distinguished Significantly Between Anger and Fear

		DBP+	*HR−*	*#GSR*	*MT+*	*SC+*	*#MTP*	*RR+*
DBP+	A	.51[a]	−.17	.32	−.12	.38	.10	.16
	F		−.11	−.10	−.08	−.03	.08	.22
HR−	A		.49[a]	−.09	−.09	−.04	−.16	−.00
	F			−.01	.10	.13	.06	.01
#GSR	A			.42[a]	−.28	.38	.00	−.12
	F				−.06	−.05	.14	−.16
MT+	A				.64[a]	−.17	.16	.24
	F					−.06	.07	−.04
SC+	A					.77[a]	.06	.25
	F						−.09	−.29
#MTP	A						.52[a]	−.01
	F							−.06
RR+	A							.26[a]
	F							

[a] The self-correlations are between anger and fear.

In speculating as to a possible integrating factor for these two different physiological reaction profiles for fear and anger, it was noticed that the fear profile resembled that produced by an injection of epinephrine while the anger profile more nearly resembled that of a combined epinephrine and nor-epinephrine reaction. Goldenberg reported that injections of nor-epinephrine produce a larger rise in diastolic blood pressure and a larger fall in pulse rate and stroke volume, while epinephrine produces a larger rise in systolic blood pressure, pulse rate, and stroke volume. Since the chief action of nor-epinephrine appears to be that of general vasoconstriction while that of epinephrine is one of increased cardiac output and reflex vasodilatation, we might predict that face temperature and hand temperature falls would be greater in nor-epinephrine, while face temperature rises would be greater for epinephrine. We know of no data which would suggest what to expect for muscle tension, respiration, or sweating changes.

The bar graph (Fig. 2) is arranged so that the eight variables in which the mean reactions were greater for anger are placed left of the dotted vertical line, and the remaining six variables in which the mean reactions were greater for fear are placed right of the dotted vertical line. The only variable in which the empirical data are in reversal to theory (of anger being like nor-epinephrine and fear like epinephrine) is the ballistocardiograph increases. This difference (although not statistically significant) may be explained by the fact that heart rates, on the average, were faster for fear, which could have reduced auricular filling of the heart and thus have reduced the stroke volume for fear as compared to anger. Another possible explanation is that since anger is presumed to be a state of combined epinephrine and nor-epinephrine, the epinephrine may have succeeded in dominating the ballistocardiograph variable.

The patterns obtained for fear and anger argue against the proposal by Arnold that anger differs from fear in that the parasympathetic system is strongly aroused in anger. Our findings that diastolic blood pressure rises and skin temperature falls were greater in anger and that face temperature rises were less in anger are each contrary to that of a general parasympathetic reaction. None of the values obtained, except the insignificantly greater rise of the stroke volume index during anger, on the other hand, is inconsistent with the hypothesis of a combination epinephrine- and nor-epinephrine-like reaction for anger and an epinephrine-like reaction for fear.

Conclusions

The results of this experiment indicate that two stimulus conditions which appeared to the experimenter and to the subjects as being properly termed "anger-producing" and "fear-producing" were accompanied by simultaneously recorded physiological reaction patterns which, on the average, were clearly different for the two stimuli for this sample of 43 subjects. These results do not refute Cannon's hypothesis of a unitary visceral excitement reaction but merely reveal a further differentiation in physiological reaction pattern. The patterns obtained for fear and anger are suggested as being similar to those produced by injections of epinephrine and a combination of epinephrine and nor-epinephrine. The intercorrelations of the physiological variables were significantly higher for anger than for fear, which was interpreted as indicating greater integration during anger.

These results provide further evidence for the psychophysiological unity of the organism in the sense that even the finest nuances of psychological events may be found to have a corresponding differentiation at the physiological level.

Summary

Forty-three subjects were stimulated in the laboratory to "fear" and "anger," during which the following physiological reactions were recorded: (1) heart rate, (2) ballistocardiogram, (3) respiration rate, (4) face temperature, (5) hand temperature, (6) skin conductance, and (7) integrated muscle potential. The scores used were the maximum rise and maximum fall from the preceding resting level and the number of responses of a critical value per unit time. Of the 14 scores thus obtained, 7 showed significant discrimination between anger and fear. Diastolic blood pressure rises,

heart rate falls, number of rises in skin conductance, and muscle potential increases, were greater for anger than for fear, whereas skin conductance increases, number of muscle potential increases, and respiration rate increases were greater for fear than for anger. *Profile difference scores,* computed from appropriate combinations of these differences, were found to be greater than zero in 42 of the 43 cases and to have a mean which deviated very significantly from zero, which rejects the null hypothesis that there is no difference in physiological reaction between anger and fear.

The patterns obtained for anger and fear argue against the Arnold proposal that anger is a strong reaction of both the sympathetic and parasympathetic branches of the autonomic nervous systems, whereas fear is but a sympathetic reaction.

Another finding was the very low correlations among the physiological reactions and the significantly higher intercorrelations for anger than for fear, which was interpreted as indicating greater physiological integration during anger.

Between-subject variance was significantly greater than within-subject variance, which supports the findings of Lacey and Malmo that there is considerable specificity in physiological response patterns.

The physiological response patterns of anger were suggested as being similar to those produced by injections of epinephrine and nor-epinephrine combined, and those of fear as being similar to injections of epinephrine.

References

1. ARNOLD, M. "An excitatory theory of emotion." In: REYMERT, M. L. (ed.): *Feelings and Emotions.* New York, McGraw-Hill, 1950, Chap. 2.
2. CANNON, W. B. *Bodily Changes in Pain, Hunger, Fear, and Rage.* New York, Appleton, 1920.
3. GOLDENBERG, M., *et al.* The hemodynamic response of man to nor-epinephrine and epinephrine and its relation to the problem of hypertension. *Am. J. Med.* 5:792, 1948.
4. LACEY, J. I. Individual differences in somatic response patterns. *J. Comp. Physiol. Psychol.* 43:338, 1950.
5. MALMO, R. B., and SHAGASS, C. Physiologic studies of reaction to stress in anxiety and early schizophrenia. *Psychosom. Med.* 11:9, 1949.
6. MALMO, R. B., SHAGASS, C., and DAVIS, H. D. Specificity of bodily reactions under stress. *Proc. A. Res. Nerv. & Ment. Dis.* 29:231, 1950.
7. MALMO, R. B., SHAGASS, C., and HESLAM, R. M. Blood pressure response to repeated brief stress in psychoneurosis: A study of adaptation. *Canad. J. Psychol.* 5:167, 1951.
8. MALMO, R. B., SHAGASS, C., and SMITH, A. A. Responsiveness in chronic schizophrenia. *J. Person.* 19:359, 1951.
9. MITTELMAN, B., and WOLFF, H. G. Emotions and skin temperature: Observations on patients during psychotherapeutic (psychoanalytic) interviews. *Psychosom. Med.* 5:211, 1943.
10. WOLF, S., and WOLFF, H. G. *Human Gastric Function.* New York, Oxford, 1947.