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THREE DIMENSIONS OF EMOTION [1]

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All of you have had to face the problems in the general field of emotion, whether your interest was theoretical or practical. I think you will agree that the field is chaotic. When you try to organize it, perhaps for presentation in a course, you probably follow one of two obvious methods. You can admit that "emotion is only a chapter heading," to quote Madison Bentley; in this case you present a sort of smorgasbord of interesting and important facts, and then go on to clinical cases or to experiments on drives in white rats, depending on your inclination. Or, if you wish a more orderly presentation of the topic, you may build it around some of the many theoretical controversies that stud the history of the field. My preference is for the latter method, and after years of following it in class, I think I am beginning to get a satisfactory integration. Let me run over the major theories, and show how they come together.

[1] This paper combines the material of two addresses: (*a*) "Some Dimensions of Emotion." Presidential Address, Div. 3, APA, Washington, Sept., 1952 Here the emphasis was on the qualitative dimensions, as found in facial expression This material, in compressed form, appears near the end of the present paper, for the technical details of the study have since appeared in print (12). (*b*) "The Intensitive Dimension of Emotion." Vice-presidential Address, Sect. I (Psychology), AAAS, St. Louis, Dec., 1952. Read before a joint session of Sections I and Q (Education).

The first controversy was between the James-Lange theory and that dictated by common sense. There seems to be little doubt that James hit upon an important truth, namely, that the responses one makes in an emotional situation are more than mere expressions of a mental state; to put a current term in James's mouth, *feedback* from skeletal and visceral responses is an important component of an emotion.

The next major controversy was between the James-Lange and Cannon-Bard theories. If we stop worrying about whether the alleged mental state, emotion, resides in the cortex or in the thalamus, much of this controversy is pointless. Indeed, we can combine the contributions of the two theories and say that the hypothalamus is the key integrating center for outgoing impulses, and also for the feedback impulses that James emphasized; in this sense, it may be the "center" for emotions as well as for drives. This brings up another theory, the motivational theory of emotions, but this theory didn't meet much resistance, for anyone with a feel for either the derivation of the word *emotion*, or for the analysis of behavior, must agree that emotion and drive are overlapping categories.

The most recent controversy was over the question of whether emotion is organizing or disorganizing. My answer to this question is, "Both." Love cer-

tainly disorganizes a student's study habits, but it does organize certain extracurricular pursuits! On the other hand, one of the most challenging tasks of the teacher is to arouse interest, a mild emotion, in apathetic students. Clearly one can't answer the general question; whether emotion is organizing or disorganizing depends on (*a*) the task under consideration, (*b*) the nature of the particular emotion, and (*c*) the strength of the emotion. Duffy (2) has long emphasized the last two points, at times suggesting that we stop talking about emotion, and substitute the direction of behavior, and the strength of behavior; for the latter she used the phrase "degree of energy mobilization." It is a troublesome term, for some people quibble about the meaning of *energy* in this context, and others worry about the implications of *mobilization*.

There are many other terms that may be used for this intensitive dimension. Cannon's concept of preparing for an emergency contains the same basic idea, but doesn't give us a good term. Perhaps the best name for the dimension is that used by Lindsley, "activation." His chapter in the recent handbook (9) gives us the outline of what he calls an activation theory of emotion. The term *activate* means a bit more than to make active; the dictionary tells us that it also means to make reactive. Activation would seem to be a very good name for what emotion does to us; the angry man overreacts to stimulation. Strong emotion thus represents one end of a continuum of activation; the other end, the condition of minimum activation, is found in the sleeping man who doesn't respond to stimulation. (If we wish to be accurate, we should put the state of zero activation at death, rather than sleep, for the sleeping man may respond to very strong stimuli. But psychologists don't study organisms at activation levels below that of deep sleep!)

To illustrate what we mean by the continuum of activation levels, let us start with a sleeping man, one near the zero level of activation. His cerebral cortex is relatively inactive, showing only slow bursts of electrical activity on the electroencephalograph. The muscles are relaxed and send few return impulses to the central nervous system. The sympathetic, or emergency, division of the autonomic nervous system is fairly inactive. As a result of this general condition, he doesn't respond to ordinary stimuli; he is unconscious.

Now let the alarm clock ring. It is a strong stimulus, and breaks through the high threshold. Gross muscular responses occur, and feed back impulses into the central nervous system. There is also autonomic discharge, and the resulting responses of muscle and gland lead to more feedback, probably through some interwoven pathways, the reticular substance. These impulses reach the hypothalamus, increasing its level of activity, and this center activates the cerebral cortex, as can be seen from brainwaves (9). In short, the individual is awake and responsive to stimulation. Perhaps I should have said, "more or less awake," for some individuals take a lot of time and activity, with resulting feedback, before the level of activation is high enough to permit anything but routine activities like dressing and lecturing!

Let us assume that our hero has reached an optimum level of activation by 10:00 A.M. He is alert, and responds efficiently to his environment. But now he finds that a book he needs is missing from his shelf. This frustration produces an increment in level of activation, perhaps not high enough at first to be dignified by the name of anger. But as he continues to search for the book the level of activation

builds up until he is "blind with rage" or "functionally decorticate" to use Darrow's term; he probably wouldn't find the book now if it were under his nose. We will leave our hero in the range of level of activation that is conventionally set off as *emotion*, but let us not forget that he started at the other end of the continuum, sleep. The tendency to consider emotion as a separate state, divorced from the rest of the continuum, may well be the reason we have made so little progress in the field.[2]

Now let us consider level of activation in a more critical fashion: How are we going to measure it? Level of activation is a construct, crude at present. It is somewhat like level of prosperity. Everyone says that our country is more prosperous now than it was during the great depression. Suppose you wish a more precise statement, and consult an economist. He will quibble a bit, but ultimately he will probably suggest the use of a composite index, preferably based on key items like commercial bank deposits and payrolls of several large industries. Our economist will warn you that this gives an index of *general* level of prosperity, and that the level may differ in specific regions or industries.

Similarly, level of activation must be a general index, at least for the present. What are the key processes that we can use? There are a host of them, traditionally listed as bodily expressions of emotions. Blood pressure, heart rate, breathing indices, and hand steadiness are typical. A very promising one is tension in skeletal muscles, preferably accessory ones, as the brow potentials recorded by Kennedy and Travis (7, 14), or the neck muscles, with their important role in posture (10). But perhaps the most widely used measure is electrical skin resistance.

The psychogalvanic reflex, or better, the galvanic skin response, has been studied by hundreds of investigators. Perhaps its chief attraction is its sensitivity in mirroring ideational activity, particularly of an emotional nature. But its very sensitivity is largely responsible for the continuing argument as to whether or not GSR is a measure of emotion, for the response may be evoked quite readily by any sudden and strong stimulus, as a loud noise or an electric shock. Fortunately, the argument largely disappears if we drop the idea that emotion is a special state; strong stimuli, preparation to make an effort, and significant ideas all have a common feature, a quick increase in level of activation. This was recognized by Landis and Hunt (8) many years ago, when they stressed the fact that GSR is associated with an increase in subjective tension. As a matter of fact, tension is probably the popular word that comes closest to level of activation.

Consideration of the physiology of the GSR also points to its value as an index of level of activation. Darrow (1) showed that the fall in skin resistance was associated with the secretory activity of the sweat glands, under control of the sympathetic system. The skin resistance thus serves as an index of sympathetic discharge, a key element in the activation mechanism. He also pointed out that it is best to place the electrodes on the palms or soles, since these areas are relatively independent of thermoregulatory sweating. Finally, he suggested the best units in which to measure the phenomenon; rather than ohms, the usual measure of resistance, he preferred mhos, the re-

[2] Lindsley ends his chapter with the sentence, "In short, the activation theory appears to account for the extremes, but leaves intermediate and mixed states relatively unexplained as yet" (9, p. 509). The present discussion is less conservative.

ciprocal unit which describes conductance. This recommendation was based on the linear relationship he observed between conductance in mhos and the rate of sweat secretion. Later he suggested the use of log conductance, but a number of recent studies show that the mho is an excellent unit; it is normally distributed, and independent of the original level of resistance.[3] Conductance has the further practical advantage that it runs in the right direction, for increase in conductance is associated with increased level of activation, increased tension. Parenthetically, it is unfortunate that more workers don't calibrate their instruments in mhos, for it is at least questionable to perform even such a simple statistical operation as averaging on a skewed measure like the ohm.

The vast bulk of research on electrical skin conductance has lost the forest for the trees. Preoccupation with transient changes, the PGR, has led to general neglect of the slow drifts in absolute level of conductance, despite the fact that the absolute level is the obvious correlate of general level of tension or activation. This neglect is partly due to the design of conventional apparatus, which is adjusted to balance out basic level of conductance so that the transient changes may be read directly from deflections of a needle. For direct measures of level of conductance a much less sensitive and less elaborate apparatus is more adequate and convenient. I use a 50-microampere panel-type meter in series with a pair of dime-sized silver–silver chloride–saline paste electrodes. The potential to run the circuit is usually one volt, obtained from a flashlight cell with the aid of a potential divider and calibrated resistor; with this voltage, the dial needle reads directly in micromhos, and the range is adequate for most subjects. The whole gadget can be assembled for about $25, and is as portable as a box of cigars. It takes five minutes to attach the electrodes and adjust the apparatus, but only five seconds to obtain and jot down successive conductance readings. Thus, a single experimenter can carry on an experiment such as reaction time, taking periodic readings of conductance throughout the session. Although I haven't tried it yet, there seems to be no reason why this apparatus shouldn't be used to follow mean conductance level of groups of ten or more individuals engaged in a common task. For example, a pair of simple and reliable electrodes could be attached to each member of a small audience and connected in parallel to one meter. Since conductances in parallel summate, one would merely have to divide the total conductance by N to get the mean. Of course, small fluctuations, as asynchronous PGR's, would balance out, but the method should be perfectly adequate to determine the general changes in level of activation during the various episodes of a play, for example.

Now let me describe a few applications, to show that conductance serves as a satisfactory measure of level of activation.[4] One of the most convincing experiments is that of Duffy and Lacey (3). They recorded skin conductance on subjects who were going through several cycles of a psychophysical task. Conductance showed a sharp increase at the beginning of the first series of tones to be judged, and slowly fell during the progress of the series and ensuing rest period. Conductance shot up again at the start of the next series, dropped off during the series,

[3] See (13) for references.

[4] Skin conductance is not an ideal index of general level of activation. But short of a compound index, conductance may well be the best available, assuming that reasonable care is taken to keep electrode contact and room temperature fairly constant.

and so on. This saw-tooth pattern continued throughout the session, showing that the subjects alerted themselves each time they started a task, and then gradually relaxed as they made progress. Further, the general level of the conductance pattern fell from series to series within each session, and from day to day; the subjects were gradually relaxing as they became more familiar with the general situation.

Schlosberg and Stanley (13) have obtained results in an extensive series of tasks and tests run in five cycles over a two-hour session on each of five successive days. In addition to confirming the Duffy and Lacey findings, these experimenters hoped to relate conductance to efficiency. They ran into difficulties in the latter respect, for there was some suggestion of a curvilinear relationship between conductance and efficiency. This is what one would expect from what we said earlier about level of activation, for it seems likely that there is an optimal level of activation for each type of task, and perhaps for each subject. For example, a moderate level of activation would seem optimal for playing chess, whereas a relatively high one would be best for sprinting. In either case, the subject would report that he was too sleepy to do well if he were below the optimal level, and too tense if he were above it.

Plausible as this idea sounds, it is hard to pin down (10), for a lot of measurements are needed on each subject before we can obtain a good curve relating his efficiency to his level of activation. Freeman (4) showed one way to do it. He took short series of reaction times and simultaneously recorded skin resistances at various times during the day, depending on diurnal variations to give a broad range of levels of activation. His results showed a very clear inverted U relationship, with minimum reaction times at a moderate level of conductance. His published data are a bit scanty to establish such an important generalization, so it seemed desirable to repeat the experiment. I set up a portable reaction timer, with a built-in device to vary the foreperiod so that it could be used conveniently at home. A student has taken a hundred sets of readings on herself, sampling all hours of the day from before breakfast to bedtime. Each session included (*a*) conductance, (*b*) 20 simple auditory reaction times, and (*c*) hand steadiness. She obtained beautiful inverted U relationships between both hand steadiness and simple auditory reaction time on the ordinate and skin conductance on the abscissa. Her optimal level of conductance for hand steadiness is a trifle higher than that for reaction time. She also ran some short series of sessions on five other subjects, and they seemed to give comparable curves. These results are encouraging, for they seem to open the way to much fruitful work in the fields of skill, efficiency, and fatigue.

But you may feel that I have gotten quite far away from my title, "Three Dimensions of Emotion." Of course I have been dealing with the level of activation continuum, but perhaps you would like some studies on the high level of activation that is traditionally called *emotion*. I don't have anything very specific to report here, for emotions are hard to produce in the laboratory. I do have another student working on the effects of electric shock on conductance during a reaction-time task, but he has been too tenderhearted in adjusting the strength of the shock However, I can at least point to the familiar lie detector test as a practical application of level of activation. The peak-of-tension method depends on a gradual increase in level of activation as the critical question approaches, followed by a marked fall in tension after the crisis has passed. Most interroga-

tors prefer breathing and blood pressure as indices of tension, on the grounds that PGR is too sensitive (6). On the other hand, the PGR has been used successfully, and it seems probable that even better results would be obtained with a device designed to measure absolute level of conductance, rather than the quick swings.

The activation theory of emotions has one obvious failing: It deals only with the intensitive dimension, and takes no account of differentiation among the various emotions. This is true as long as we limit our consideration to *general* level of activation, forgetting the fact that different subsystems might vary more or less independently in different emotions. The situation is quite analogous to that in the closely related field of motivation. Both hunger and thirst will raise the general level of drive, as measured on an activity wheel, but each will also act selectively on an appropriate family of S-R units. Unfortunately, the analogy isn't complete, for we haven't yet found differentiated emotional patterns as clean-cut as are eating and drinking. There are a few hints of such differentiation among bodily changes in the various emotions, but we need much more research before they can be established.

However, there is one field within the topic of emotions where we have long been embarrassed by the excessive number of different patterns: This is the field of facial expressions. Frois-Wittmann (5) brought some order out of this chaotic field by working out the interrelations among various expressions, and Woodworth (15) contributed a six-step scale that helped a lot. In 1941 Schlosberg (11) used this scale for collecting data on a new series of pictures, and found evidence that the scale described a roughly circular surface. Inspection of pictures arranged around the scale suggested that the surface might be generated by two axes, pleasantness-unpleasantness, and attention-rejection. The next step was to try to get a better description of the surface in terms of these two axes. In 1952 Schlosberg (12) reported the results of several attempts to obtain independent ratings on a large number of posed expressions, using nine-point rating scales, one for each dimension. Pleasantness-unpleasantness offered no trouble, but there was considerable difficulty in explaining the attention-rejection dimension to the judges. We tried pointing out that rejection was the active opposite of attention, characterized by compressed lips, nostrils, and eyes, as though forcibly excluding the external object, but this effort met with only mediocre success. We finally hit upon the use of "anchors"—pictures selected from another series to illustrate the extremes of attention and rejection. This stabilized the ratings and enabled us to locate each expression on the roughly circular surface described by the two dimensions, P-U and A-R. These positions were validated by using them to predict Woodworth scale judgments of the same pictures. The predicted Woodworth scale positions correlated with the obtained ones with coefficients of .92, .94, and .96 in three independent experiments, utilizing two different sets of photos of posed facial expressions. Hence, we may feel considerable confidence that P-U and A-R are two basic dimensions of facial expressions in particular, and perhaps of emotions in general.

We can compare the two dimensions of the facial-expression surface to the blue-yellow and red-green axes of the color surface. This immediately suggests that there may be a third dimension, corresponding to visual brightness. The third dimension for facial expres-

sions might well be the intensitive one we considered earlier, level of activation. As a preliminary test of this possibility, we obtained ratings on the same pictures, this time using a rating scale that ran from sleep to tension. The results enable us to construct a crude three-dimensional figure, roughly comparable to the familiar Munsell color solid, and quite as irregular in shape (Fig. 1). The unpleasant pictures tend to show the highest levels of activation, with mirth at an intermediate level, while contempt, which combines pleasantness with rejection, has a rather low level of activation. The third dimension seems to clear up some expressions that are not separated by the original two axes; for example, grief, pain, and suffering all have the same P-U and A-R values, but grief is rated considerably below the other two expressions in level of activation.[5]

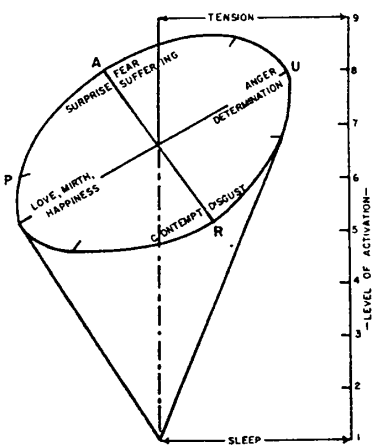

FIG. 1. A first approximation to the solid figure which represents the range of facial expressions. The emotions are placed correctly with respect to their maximum level of activation (sleep-tension) indicated on the ordinate. The top surface is sloped to show that anger and fear can reach higher levels of activation than can contempt. For a more accurate representation of the other two dimensions, pleasantness-unpleasantness and attention-rejection, see (12).

Much more work has to be done before we can be satisfied with the intensitive dimension of facial expressions. For one thing, we were working with a collection of pictures posed to represent emotions; this concentration on one end of the continuum introduces "series effects" in the ratings. We need a wider range of pictures, including low levels of activation such as sleep or listening to a dull lecture. Further, we should have actual skin conductance readings on the individuals, taken just before each picture was snapped. But these are projects for the future.

SUMMARY

The activation theory of emotion brings together many of the theories and facts of emotion, at least as far as the intensitive dimension is concerned. Instead of treating emotion as a special state, differing qualitatively from other states, the theory locates emotional behavior on a continuum that includes *all* behavior. This continuum, general level of activation, has its low end in sleep, its middle ranges in alert attention, and its high end in the strong emotions.

Any one of a number of physiological processes may be taken as an index of general level of activation, but electrical skin conductance has certain advantages for the purpose. It is sensitive, easy to measure, and varies in a manner consistent with expected changes in level of activation. It promises to be equally useful in work on skills and efficiency, as well as on emotions.

Neither skin conductance nor any other physiological measure of level of

[5] The three dimensions attempt to describe pictures of the *responses* called facial expressions. Knowledge of the situation which evoked a given expression will help the judge to interpret the expression, but such situational cues need have no part in the description of the response per se.

activation has yet given us much beyond the intensitive dimension. Further research may furnish such evidence, but for the present we may profitably turn to facial expression to find the qualitative dimensions along which emotion may vary. Here, we have good evidence that the whole range of expressions may be described rather well in terms of a roughly circular surface, whose axes are pleasantness-unpleasantness and attention-rejection. We have some idea how level of activation comes into this figure as a third dimension, but further research is needed here, too.

Thus, facial expressions and body changes supplement each other in giving us the dimensions along which emotions may vary.

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