*Motivation and Emotion, Volume 1, Number 2, 1977*

# Homeostasis, Discrepancy, Dissonance

## A Theory of Motives and Motivation[1]

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*The argument is presented that motivation is equated to energy mobilization, and that the mechanism involved in all such instances of arousal is a discrepancy-detecting and -reducing mechanism. Motives are specific categories of discrepancy but they operate through a common arousal system. This system, further, may be coopted into (integrated into) processes involving social comparison, relative deprivation, discrepancies with respect to ego-involved persons and objects, and industrial, social, and political motives. While biological homeostasis provides the basic CNS system, other forms of discrepancy-triggered energy arousal must be recognized as important. Hedonism and theories of curiosity, as well as other similar factors, can be subsumed under discrepancy theory.*

The state of psychological theorizing regarding motives and motivation was described by Madsen (1968) as "complicated and confusing." The situation has not improved in the interim.

Madsen's book offers a detailed comparison of several theories, using a variety of philosophical criteria. However, he does not point the way to any unifying principles which might cut across the various theories and simplify the confusing profusion of interpretations. The present paper will offer a set of propositions which seem to have promise as they identify common factors in the various theories, and which also are compatible with the major trends in empirical research on motives and motivation.

Some of the confusion in the field is a function of different perceptions by psychologists as to the phenomena to be covered. There is at least one major dichotomy, between those who emphasize energy mobilization

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[1] A portion of this paper was prepared with the support of NIMH Fellowship 1-F03-MH-54564-01.

(Duffy, 1951) and those who emphasize goal-directedness (Fuller, 1962). One way to cope with this distinction is to limit the term *motivation* to differences in energy, effort, or arousal, and to retain the term *motive* for a motivational state which has directional properties.

It may be helpful to approach this question at a very simple level. If we want operational definitions of concepts, we begin with variations in behavior. One class of variations can be categorized by reference to the vigor with which action is carried on, the persistence and the directedness of action. The adjective *motivated* is used to identify action in which the energy level is high and behavior is persistent until some goal or state is attained. *Motivation* is an abstract concept used to label this dimension of variation in behavior. *Motive* can then be reserved for labeling a specific organismic state, such as hunger, thirst, or sex, arousal of which predictably sets off energetic behavior toward predictable goals and which can be used as a concrete example of the abstraction *motivation.*

Elizabeth Duffy (1951) asserted years ago that the focus of psychological thinking should be on energy mobilization, not on hypothetical "motives." The point is sound if we are concerned primarily with a description of behavioral variation. If, however, we are interested in identifying the independent variables which can be manipulated to induce energy mobilization, we must extend our analysis considerably. This paper proposes the thesis that energy mobilization is predictably related to a class of events which have in common a *discrepancy* between the registered or "expected" value and the input value of a relevant variable. The argument is presented that the biological concept of homeostasis provides a framework and a mechanism which can integrate such views of motivation as are associated with terms like *dissonance, need achievement, competence,* and *self-actualization* into a biologically based theoretical structure, without redefining these concepts to the point of distortion.

A theory of energy mobilization must be anchored in biology, but it should also have relevance to the world of industry, politics, religion, and other social phenomena.[2] Unfortunately, most of our current theories are conceived within and supported by a very narrow range of observations. Conversely, few practitioners have bothered to speculate about the theory of motivation, although they rely heavily on motivational principles in their daily work. Industrial practice, for example, indicates that a variety of incentives may elicit the same degree of effort, i.e., arousal. Psychological theorizing should take account of work done in these nonlaboratory settings as well as the more precise experimental data.

[2] This is not meant to imply that every theory must have immediate practical implications. However, there is a need for theorizing which takes account of a "world out there" where real people have jobs, obtain an education, develop neuroses, and otherwise indicate "motivation."

A concern with general principles of motivation applicable across areas need not imply the disregard of situational specificities. The analysis of instances of energetic or lethargic behavior will point to environmental variables which induce "inconsistencies" in the operation of general principles of energy mobilization. The argument here will be that we must first identify the *consistencies* in manifestations of effort, and then determine the constraints or modifiers which must be considered in the prediction of behavior either for groups or for individuals.

## I

The term *motivated* traditionally applies to two kinds of variations in data. Nomothetically, *motivated* has referred to behavior characterized by an elevated effort or energy level in a given organism; e.g., a hungry animal works harder to obtain food than the same animal when satiated. Idiographically, *motivated* has referred to a characteristic of a person; a man may be described as highly motivated toward prestige or toward sexual gratification or toward accumulation of wealth.

The present discussion will focus on the nomothetic problem. We shall also assume that level of energy mobilization deserves priority over direction of effort; after all, if we seek to study the direction of energy, there must first occur some variations in energy which can be directed. A separation of the two aspects is clearly artificial but equally indispensable. It is proposed, therefore, to focus primarily on a theoretical analysis of variations in energy level (motivation); directionality (motive) will necessarily enter the argument on occasion but will not be the center of attention.

Variations in level of effort may be functions of internal or of external "independent variables." This is again a somewhat arbitrary choice, in the sense that motives, considered as inner biological states, are triggered by events outside the organism or at least external to the CNS. Hunger, for example, is an intraorganismic phenomenon but it is traceable directly to the lack of food in the immediate milieu. "Dialectical psychologists" are thus correct in asserting that the agency inducing behavioral change is the external variable; temperature, water, food, sexual objects are all properly categorized as material conditions affecting man's energy level.

On the other hand, long usage commends the restriction of "motive" to internal conditions. Deprivation of food is an objective event but it has no psychological significance until internal changes have occurred. These, in turn, are in part functions of metabolism, not just of the lack of a food supply. The relation of the external event to the inner process of mobilizing energy is thus statistical but not mechanical. In the long run we can be sure that the external change will lead to effort; in the short run external deprivation may or may not induce inner motivation.

A related consideration is that of the principle of parsimony. Many psychologists have been remarkably free in their tendencies to postulate large numbers of motives. McDougall at various times suggested 15 to 22 specific and presumably independent motives. Cattell (1957) speculates that there are 16 "ergs." Maslow (1970) assumes 5 or 7 "basic needs." Murray (1938) thinks there may be as many as 25 needs.[3] Some psychologists demonstrate a freewheeling tendency to invent new motives to meet any observed requirement of an energizing component. Festinger (1954), for example, postulated for human individuals "a drive to evaluate his opinions and his abilities" and derived from this a "need" to compare the self with others and to eliminate discrepancies in these comparisons.

It seems far from parsimonious to postulate motives like this for every major human activity, and in any event, Festinger does not link this assumed social-comparison tendency (nor the dissonance tension) with biology in any fashion. Thus, to the extent that the dissonance research identifies significant energy-mobilizing processes, it is important to incorporate these into a network of relations with known biological energizing phenomena.

Occam's razor may be used to cut down on the number of motives to be hypothesized, but only if we can offer a logically acceptably alternative. The rule is: Entities must not be multiplied *beyond necessity.* It is proposed that multiple motives are not necessary. The alternative is to postulate a single motivational mechanism with multiple triggers. Many motives can feed into a single system, and many responses can be energized by that system.

A first assumption, therefore, would be: *Energy mobilization is a single process which varies in degrees, and which may be integrated into varied goal-directed action patterns. Motivation* will refer to this generalized process. *Motive* will be used to identify specific deprivations, discrepancies, or expectancies which trigger energy mobilization.

A clear implication of the foregoing is that energy mobilization is a reliable phenomenon, i.e., that it will be internally consistent when measured by different operations in the same situation. Unfortunately, the data present problems for us at once. For example, Anderson (1938) used measures such as speed of running to food, time spent in digging through sand to reach food, number of crossings of a charged grid to obtain food, and so on. Each of these seems plausible as a measure of energy mobilization due to a given degree of deprivation of food. Unfortunately, the different

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[3] The term *need* is not incorporated in this proposal. The reason is that, while a deficit of some input is undoubtedly relevant for some *d* phenomena, the term has been used in such diverse ways as to be confusing rather than illuminating. What, for example, is the "deficit" implied by a "need for abasement"?

measures correlate poorly. For example, the operational indices of intensity of hunger drive, such as time taken to dig through sand to food, or crossings of an electrical grid to reach food, have correlations ranging from −.17 to +.34, not an encouraging indication of a generalized level of arousal. Similarly, several studies have shown that hours of food deprivation may not be a consistent index of "hunger drive," and all other indices which have been tried have proven to be of dubious value.

It may be argued, therefore, that we should discard the concept of motivation both as it relates to changes in energy level in a single organism and as it refers to variations among persons with respect to effort and industry. If the evidence indicates inconsistent performances, perhaps no theoretical construct should be postulated tying these phenomena together.

An alternative is suggested by Kurt Lewin's (1935) postulate of the "hypothetical pure case." As Lewin noted, the falling of leaves, feathers, stones, and other physical objects is highly inconsistent. Nonetheless, Newton hypothesized a principle of gravitation and demonstrated that under highly special circumstances (vacuum), bodies do fall toward the center of the earth at a uniform acceleration.

This logical approach would suggest that, despite the phenotypical inconsistencies of "motivated" behavior, we may be able to salvage the concept of motivation by searching for abstractions ("genotypes") which characterize different events, and by identifying some of the environmental variables which introduce error variance into the efforts at measuring the "pure" phenomenon of motivation. This paper offers some speculations in that direction.

## II

The pure case to be utilized in this discussion is that of a discrepancy between a preferred or "normal" steady state and the input of stimulation appropriate to that steady state. It is proposed that the following general principle holds for all instances of energy mobilization: *The organism manifests an increase in energy level when it encounters a discrepancy between current input and the established or preferred steady state with respect to that input. The increased level of effort tends to persist until the discrepancy has been removed, and the degree of increase in effort is proportional to the magnitude of the discrepancy.*

Psychoanalysts will recognize how closely this parallels the assertion by Sigmund Freud that "the nervous system is an apparatus which has the function of getting rid of the stimuli which reach it, or of reducing them to the lowest possible level" (1954, vol. 14, p. 120). The proposed modification amounts to replacing the word *stimuli* with the word *discrepancies.* The reason for this substitution will become apparent when we consider some of the circumstances under which energy mobilization can be demonstrated.

*The Neuronal Level.* Lillie (1923) noted that any stimulus exceeding the threshold value for a receptor cell (inducing firing of this neuron) disturbs the sodium–potassium equilibrium along the cell membrane. Such disturbances, of course, often die away without activating other cells and hence without affecting behavior. However, if the disturbance excites enough neurons, or maintains excitation for a long enough period, a whole system will be activated and some response will ensue. From this, some psychologists have inferred that energy mobilization is merely a function of stimulus intensity and duration. A very weak stimulus may elicit no detectable response; the reaction to a wisp of cotton is not like that to a red-hot branding iron. A very strong stimulus may evoke panic or disorganized, convulsive behavior. For present purposes it is preferable to emphasize that the stimulus represents a discrepancy (*d*) from the current resting state of the receptor system; the amount of energy mobilized will be a function of this *d.* (The problem raised by differences in the "meaning" or symbolic significance of the stimulus are not relevant at this point.)

*The Orienting Response* (*OR*). This is another, more complex example of arousal. Sokolov (1963) identified an interesting case of OR when a repetitive stimulus habituates, OR disappears, and then a cessation of the stimulus reinstates OR. A discrepancy from the expected input elicits arousal. The interpretation seems to be that the "neural model" produced by repetition is suppressed by developing collateral inhibition, but a modified input escapes this inhibitory influence.[4]

A point in the Sokolov analysis which is especially relevant here is his postulate that the magnitude of OR is proportional to the difference between the brain representation of the *present* stimulus and the neural model of *prior* stimulation. This suggests a concept of discrepancy similar to that in the earlier section on the neuronal level.

The importance of stimulus intensity, habituation, and the OR as models of energy mobilization on a microscopic level can be clarified by relating them to the position taken by Sigmund Freud on organism–environment relationships. Freud felt that the organism was vulnerable to excessive stimulation and had to defend itself. He considered that some kind of protection against stimulation was indispensable in "an external world charged with the most powerful energies. . . it would be killed by the

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[4] Incidentally, this may be the most microscopic example of Piaget's concepts of assimilation and accommodation. If the change *in* input is minimal, assimilation ensues and no OR is manifest. A change in input which exceeds the threshold prevents assimilation and is processed as a "new" stimulus. Repetition of this changed input will induce change of the schema, i.e., accommodation.

stimulation emanating from these if it were not provided with a protective shield against stimuli..." (1954, vol. 18, p. 27).

*Adaptation Level* (AL). The role of thresholds, habituation, and energy mobilization to intense or discrepant stimuli can be further clarified by reference to research on adaptation level (AL). Helson (1964) points out, as would follow from the habituation research, that the stimulating effect of a repeated stimulus tends toward zero. If adaptation (habituation) is complete, the stimulus elicits no response, no increase in energy level. However, a stimulus deviating by at least one j.n.d. from this AL does evoke effort and response. We see this in children accustomed to the noise of radio and TV, who become restless and fretful when afflicted by silence. Adults accustomed to solitude become quite aroused when placed in a crowded room.

*Homeostasis.* The foregoing examples refer to energy mobilization induced by *external* events which resulted in disturbance of an inner equilibrium. Metabolic changes within the organism can have a similar effect. The body uses up the available glucose in the blood, and "hunger" develops. More precisely, we can say that there is a center in the hypothalamus which registers a certain optimum or expected level of glucose. If the input (level in the blood stream) falls below this level by a threshold amount, energy is mobilized and action initiated to restore the proper equilibrium.[5]

There are many homeostats in the hypothalamus. Empirical support has developed for registers of steady states (hereafter, *ss*) for glucose, pH, osmotic pressure, temperature, and a variety of other inputs essential to protoplasmic survival. We suggest that each of these corresponds to a *motive* in the sense of a system which will (1) elicit energy mobilization, and (2) direct effort toward achieving some input needed to eliminate the discrepancy in the system. The key concept here, discrepancy (*d*), can be defined as (*ss*−*i*), the deviation of the input value from the preferred or expected value.

Many highly respected scholars espouse the principle of homeostasis enthusiastically and completely. Menninger (1963) asserts that "*all human behavior* represents the endeavor on the part of an organism to maintain a relatively constant inner and outer environment by promptly correcting all upsetting eventualities" (p. 84, italics added). Similarly, J. Z. Young (1971) takes the position that "this capacity for maintenance of continuity, or *homeostasis,* is the central, characteristic, feature of life" (p. 8, italics in original).

[5] Preloading the stomach with a glucose solution reduces food intake by an amount closely proportional to the corrected glucose deficit (McHugh et al., 1975). It has also been shown (Nicholaidis & Rowland, 1974) that rats will maintain normal osmotic pressure by bar-pressing to give themselves intravenous water injections.

Against these, of course, must be set the judgments of many who reject homeostasis or relegate it to a very restricted role. Bolles (1967) summarizes his view as follows: "In recent years all of these different lines of evidence for this picture of need–drive–goal-seeking have come under experimental and theoretical attack. The day now seems far removed when Rignano . . . and Raup . . . could enthusiastically propose that homeostatic principles could explain all psychological activity. . . . [W]e now know that this picture of automatic adjustment was much too simple" (p. 118). But perhaps the picture Bolles examined was oversimplified.

A sophisticated presentation of homeostatic theory requires consideration of the *d*-mechanism, which detects deviation from an established steady state (*ss*); an arousal mechanism, which triggers increased activity, physical or mental; and goal-objects, which will, when contacted by the organism, restore *ss* and reduce *d.* Goal-objects may be classified as *proximal* incentives which immediately reduce *d,* and *distal* incentives which *signal* reduction of *d.* Glucose in the blood would be a proximal incentive; candy on the table is a distal incentive. The difficulties envisioned by Bolles mostly involve this difference, which resembles the traditional distinction between "primary drives" and "secondary drives."

*Dissonance.* The hypothesis that the basic mechanism involved in human arousal processes is a discrepancy-detecting and discrepancy-minimizing system can link Festinger's (1957) theory of dissonance to homeostasis. Festinger's logic began with the perceptual process, the tension evoked when incoming cues conflict with established expectancies in the perceptual world. It is thus similar to Helson's view that deviations from AL are arousing. Festinger's experiments showed that if he induced a discrepancy between "what I think of myself" and "what I have done," the subject would exert effort to reduce this *d.* In the Asch conformity studies, individuals reported marked increases in subjective tension when discrepancies were arbitrarily created between the registered visual value for length of line and the input from confederates. Such a conflict situation also elicits physiological arousal as measured by palmar sweating (Lawson & Stagner, 1957).

*Economic Motives.* The discrepancy concept has proved valuable in the analysis of man's industrial behavior, and of his economic activities in general. Porter (1962) hypothesized that the gap between what an employee perceives to be the present input of a given desideratum (security, recognition, promotions, pay) and what he expects or considers appropriate to his education, seniority, skill level, and job duties would have substantial relationships with measures of job satisfaction, turnover, absenteeism, and other forms of behavior found in industrial settings. Likewise, the entrepreneur is energized by discrepancies; e.g., he may be concerned about the gap between his share of the market and what he aspires to achieve, or about the gap between his expected profit and the obtained profit figures.

For both workers and employers, discrepancy theory seems essential to an adequate description of effort and energy.

A somewhat more elegant model for the interpretation of industrial motivation as discrepancy is offered by Katzell (1964). The proposed formula takes the form:

$$d_X = f[(X_i - V_X)/V_X]$$

in which $d_X$ is defined as a departure from maximum pleasantness, $X_i$ is the magnitude of the incentive (e.g., salary) involved, and $V_X$ represents the magnitude of a stimulus of type $X$ which is most pleasurable. To give a simple example, we can say that $d_X$ is the discrepancy of received salary from expected or aspired salary. A man paid $20,000 a year when he believes his services to be worth $25,000 suffers a discrepancy of $5,000 and $d_X = .2$. The Katzell formulation thus proposes that energy will be mobilized to correct a discrepancy as defined, and that the amount of energy will be proportional to $d_X$. This, of course, is a Weber fraction, hence, values of $d_X$ less than one j.n.d. will not be energizing; e.g., an executive receiving $100,000 a year ($X_i$) will perceive a $d_X$ of $2,000 as trivial[6] and immaterial. On the other hand, Katzell probably should incorporate a time parameter by modifying the j.n.d. or $d_X$ threshold value, in that persistent or repeated discrepancies may be more energizing than one-time or short-lived incidents.

*Social Comparisons.* The foregoing example suggests that, like metabolic discrepancies, social discrepancies have motivational implications in accordance with social comparison theory. As Festinger (1954) indicated, dissonance may or may not motivate an individual, depending on the comparison standard used by the person to define an expected value. Social psychologists have utilized the concept of *relative deprivation* to identify the phenomenon of arousal due to a discrepancy from some reference group or anchor stimulus, as opposed to absolute deprivation, which implies a discrepancy from an innately determined *ss*.

*Equity Theory.* Another theory of motivation in the industrial situation is that of Adams (1963). Like Katzell, Adams emphasizes a balance between inputs and outcomes, i.e., the relationship between what one receives and what one thinks he should receive. Input, in this context, refers to skill, education, seniority, job difficulty, and other factors, which would imply an entitlement to higher return than if the person lacked some of these attributes. Obviously this is dependent on social comparison processes; the in-

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[6] A small objective discrepancy may, however, be magnified by symbolic threat and perceived as a large prestige discrepancy. If one corporate vice-president receives $100,000 per year and another $102,000, the former may perceive this trivial *d* as a major ego threat.

dividual arrives at a feeling that he is compensated equitably by comparing himself with others. Equally obviously, this is another situation in which *d* is the trigger for effort.

*Some Constraints.* The foregoing paragraphs provide illustrations of the remarkable extent to which the discrepancy principle unifies a wide range of energy-mobilizing situations. The principle implies a set of *predictable relationships between magnitude of discrepancy and levels of effort* in various situations. The principle can be sustained if we accept the notion that it holds rigorously only for pure cases, and that in practical everyday affairs, or even in the laboratory, physical and social constraints may modulate the energy output.

We noted earlier that Anderson's rats did not show a uniform index of arousal when this was computed by varying operations. Many factors could contribute to such variation. For example, the operation of digging through sand to reach food involves different movements, different muscles, and different environmental obstacles from those involved in running down an alley to food. Thus environmental constraints may function to interfere with simple, straightforward prediction from magnitude of *d* to magnitude of measured energy mobilization.

The same exceptions operate on a wider scale for human activities. The motivation of a worker on an assembly line, for example, is conditioned by his financial needs, but the degree of exertion is held within narrow limits by the machinery he services; beyond this, his effort will be affected by his relations with his fellow workers and his union, to mention only two important social constraints. It is thus naive to expect that a mathematical prediction of effort from discrepancy will be highly accurate. Nonetheless, the logic of the situation supports the assertion that there is a significant relationship. We may therefore postulate that energy mobilization is a function of *d,* but that level of behavioral effort may be modulated by a number of factors.

As Walker (1956) pointed out, the homeostatic approach to motivation, with its emphasis on the energizing effect of discrepancy, has a close resemblance to Freudian theory. "Freud's use of the concept of homeostasis," he wrote, "in the hypothesis that 'the nervous system is an apparatus having the function of abolishing stimuli,' is of great interest, . . . it is the unifying concept that links together the wish-fulfillment explanation of dreams, the defense-mechanism of the ego and the repetition compulsion" (p. 61). The role of Freud's hypothesis in psychoanalytic theory is not germane to the present discussion. It is, however, relevant to the assumption here that discrepancy abolition can be a unifying principle for a variety of energy-mobilizing situations. Minimal violence is done to Freud's theory by paraphrasing his assertion in homeostatic terms: "The nervous system is an apparatus for detecting and reducing discrepancies."

*Hierarchical Arrangement of d.* One of the many difficult problems for motivation theory is that of hierarchical differences. Some discrepancies necessarily are going to override others. Some *d* are so weak that they can be observed only under special circumstances. Some are so close to issues of organismic survival that an evolutionary logic dictates prepotency for them.

The amount of energy mobilized by different modalities of *d* will therefore vary. A visual or auditory stimulus without symbolic significance is only slightly arousing. By contrast, *d* affecting a homeostat such as that for osmotic pressure will release substantial energy persisting for some time. The social motives, such as relative deprivation or inequity, tend to be weaker than *d* related to biological *ss.* However, we must recognize that the organism's reinforcement history, valences associated with certain cues, and probabilities of eventual goal-attainment will operate to produce some personalities whose behavior manifests a hierarchy differing from that proposed by Maslow (1970).

*The Final Common Path* (*fcp*). The concept of a hierarchy of *d* implies that there is a final common path (*fcp*) which is unitary and can be activated by only one *d* at a time. This is similar to but not identical with Hull's (1951) concept of *d* as an intervening variable evoked by one of a variety of needs, and in turn modifying the probability of a given response (sHr). The *fcp* assumption is important for discrepancy theory because a major purpose of the theory is to link biological motives with social motives. This means that a system activated originally by metabolic *d* can be, after learning, triggered by social *d.*

The *fcp* also serves to explain the failure of drives to summate. Generally the effort level is that appropriate to the strongest motive operating. In the proposed formulation *fcp* operates at the level appropriate to the prepotent *d,* unaffected by other *d*-states.

*Expectation of Discrepancy* ($E_d$). As indicated above, *d* is conceptualized as a receptor process or, more precisely, an outcome of a comparison of input with a recorded value. Classical conditioning operates to establish expectancy of such a discrepancy. It is therefore postulated that repeated discrepancies, or long-enduring or intense discrepancies, become conditioned to interoceptive or exteroceptive cues, inducing a new intervening variable, $E_d$, the expectancy of a discrepancy. Since anticipation of deprivation or frustration is threatening, it is also appropriate to think of $E_d$ as a threat-expectancy.

## Some Proposed Principles

The points proposed so far with respect to motivation and arousal may now be formalized as follows:

1. *States of equilibrium* (*ss*) *reflect normal operating values for the organism.* For the homeostats, *ss* is recorded in centers in the hypothalamus.

2. *Discrepancy* (*d*) *occurs when input differs from ss by some threshold value* ($d = ss-i$). Any *d* may trigger an arousal mechanism, the final common path (*fcp*), which increases the level of effort.

3. *The magnitude of energy mobilization is proportional to the magnitude of d.*

4. *The arousal mechanism* (*fcp*) *gives rise to specific and nonspecific consequences.* Specific consequences are those tied to a given *ss,* as in respiratory or digestive systems. Nonspecific consequences are manifestations of ANS and endocrine activation. Nonspecific elements may become dissociated by a process of differential fractionation (DF) of primitive ANS systems.

5. *Values of d from different modalities are arranged in a hierarchy* in which those based on tissue conditions (neuron state, homeostat) inhibit other *d* processes and govern behavior until the prepotent *d* is reduced.

6. *Satiation occurs when appropriate inputs restore ss and reduce d to zero or to a minimal value.*

6a. *Satiation is relatively predictable for the prepotent* (*biological*) *d, but is subject to considerably more constraints in the case of social ss.* For example, attainment of a desired value of wealth or prestige may not satiate and reduce arousal level; this is ascribed to the fact that the distal incentive is symbolic and no chemical or biological feedback occurs to inhibit the arousal *fcp.*

7. *Repeated, intense, or long-enduring d leads to the formation of discrepancy-expectancy,* $E_d$. This obeys principles of expectancy learning, and is relatively nonsatiating, depending on extinction processes which do not operate predictably at this level.

7a. *Repeated d leads to the establishment of a quantitative scale for estimating the magnitude of the distal incentive required to reduce d.* The organism has an anticipatory mechanism which feeds forward to guide ingestion of the incentive and terminate it even before *d* has been effectively reduced to zero.

7b. *Repeated d leads to the development of forestalling tactics which reduce the probability of d.* Thus the organism may accumulate supplies of food or of wealth which are perceived as protective. $E_d$ will then energize vigorous activity if these supplies are threatened.

## III

The two key concepts in this theoretical approach are *d* and *ss.* The latter term requires closer examination. It is used here to refer to an equilibrium or resting state which is favorable to survival. However, by extension, it will be used for preferred or expected states. The logical basis for this extension can best be sketched by identifying the sources of important *ss*.

## Sources of SS

Homeostatic theory asserts that the primary task of the organism is to maintain and protect certain inner constancies, biological *ss*. It is postulated that each *ss* is recorded in a neural center or system, most of them in the hypothalamus, and that energy is mobilized when a discrepancy, *d*, develops between the current input and this recorded value. Before exploring the questions raised by this assertion, we must ask: What are the origins of *ss*?

*Heredity.* Obviously some of these *ss* must be determined by the genetic code. Human cells are viable at certain pH levels, with some minimum level of glucose, minerals of various kinds, oxygen, and other elements. A process of natural selection ensures that normal human babies will be "set" for survival values of these inputs.

*Prenatal AL.* It is not necessary that every *ss* observable at birth be genetically determined. The infant has just spent 9 months in an environment which has varied within extremely narrow limits (because of homeostatic processes in the mother's body). It seems entirely possible that such *ss* as body temperature (37°C) may have been set by the AL process. This is made plausible by the fact that, as autonomous organisms, we can become adapted to environmental temperatures over a substantial range. The importance of prenatal learning is attested by the recent observation that distressed infants are soothed by an audible recording of a maternal heartbeat. This input would reinstate an expectancy of comfort and elimination of tension.

*Imprinting.* The behavior of young organisms which show the imprinting phenomenon suggests that this creates, rather rapidly, a new *ss*. The chick imprinted on a red balloon will emit distress noises when the balloon disappears and stop when it returns. Chicks placed in a warm nest will leave it to go to a cold room to be near the balloon, showing that the imprint is more potent than the *ss* for temperature.

The potency of imprinting as *ss* is indicated by Hoffman, Eiserer, Ratner, and Pickering (1974). In their studies, chicks were imprinted on a moving object, and as expected, made distress noises when the object disappeared. Repeated appearances and disappearances caused the distress vocalizations to become more intense and more persistent. It is thus clear that the repetition of an imprint does *not* induce habituation, and likewise, repetition of a discrepancy does *not* weaken the response. (This is true only within a limited range of time and frequency; as will be noted below, if the organism comes to expect that the goal-object is unattainable, energy mobilization in that area will cease.)

*Postnatal AL.* At least some *ss* are docile, in Tolman's sense of that term. That is, *ss* for temperature may be 37°C at birth, since the foetus has been well adapted to that level. But if he/she lives in a chilly environment, he/she may come to expect and even to prefer a lower external temperature. Similarly, expectancies with respect to noise, crowding, levels of praise and affection, physical fatigue, and other factors may be modified by repeated experiences and a new *ss* may be constructed or an old one modified.

*Conformity.* Peer group pressure may establish a new preferred *ss.* This may relate to sound pressure, as in rock music, or to tastes and odors, dress, and so on. The child may seek to conform to parental patterns or may rebel against them and establish new goals. He/she develops not only a self-image, but also an ideal self-image, which is usually a summation of the inputs from parents, teachers, religious influences, and peer pressures. There is an extensive literature indicating that discrepancies with respect to these various "expected levels" may have substantial arousal value.

*Instrumentality.* Finally, we must note that objects, persons, and activities which have led to tension reduction in the past may be perceived as continuing to have this effect. The individual may thus value their presence, just as the imprinted chick values the object used for imprinting. Money, clothing, status symbols, tools, and other items instrumental to reduction of *d* at the biological level can acquire value and function as *ss.* Energy will then be mobilized to protect them, or to restore any which are disturbed.

All of the foregoing states (examples of *ss*) have one property in common: This is that deviation from *ss* evokes effortful behavior which tends to continue until *ss* is restored. The argument, therefore, centers on the notion that there is a hypothetical pure case in which all energy mobilization can be related to the occurrence of *d.* It is not implied that all *ss* are identical in any other sense. It is also indicated that a specific motive (*ss*) will give rise to correlated reflexes and other indices of arousal which differ from the consequences of arousal based on any other *ss.*

## IV

The discussion so far has assumed that the mode of operation of the discrepancy-reducing mechanism was fairly obvious. In the case of the biological homeostats this should be true. The organism has a prerecorded value for a given class ("modality") of input, such as glucose or water. The homeostats are receptors, sensitive neuron clusters which report to the CNS on a match, or mismatch, of input and *ss.* It is, however, important to keep

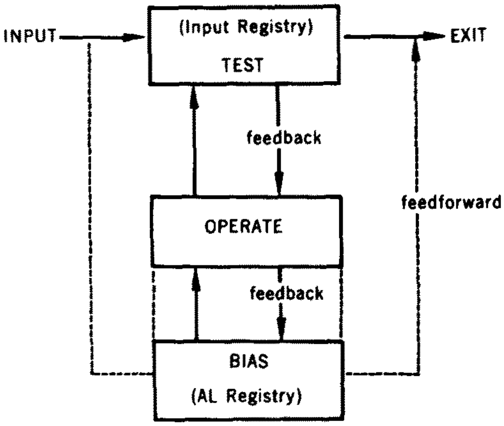

**Fig. 1.** A modified TOTE unit. The extent of energy mobilization is a function of the discrepancy between "bias," or the registered value expected for this input, and the actual input. Feedback functions to maintain or terminate the "operate" system; feedback also modifies the bias (expected value changes to accommodate to repeated inputs). Feedforward "sets" the point at which the discrepancy is eliminated and action ceases.

in mind that both the value of *ss* and the threshold value for *d* are subject to modification by experience.

This hypothesis is well illustrated by the TOTE unit described by Miller, Galanter, and Pribram (1960). This hypothetical construct is represented in Figure 1, which is a third-generation offspring of the original design. (Pribram, 1971, introduced some modifications, and Figure 1 introduces still other changes.)

It will be remembered that TOTE is an acronym for "test, operate, test, exit." Simply stated, the organism tests the environment for level of input, e.g., of pH of the blood. If this test reports a discrepancy from the normal or preferred level, the CNS "operates," i.e., activates the respiratory nucleus to eliminate more carbon dioxide and thus raise the alkalinity of the blood (or vice versa). If a second test indicates a match of input and normal levels, the unit "exits," i.e., ceases operating.

As Figure 1 suggests, even this simplified sketch involves a number of components. The "bias" is the registered proper value for some modality—glucose, pH, osmotic pressure, etc. The bias sets up a criterion for ending the period of arousal by a "feedforward" loop. This mechanism may be supplemented by a shutoff system called satiation or satiety. Feedback from the operation may also function to change the bias, in the case of AL and comparison processes. This simply means that, contrary to some critics, homeostatic theory does not predict that the organism always reinstates a prior state. The bias value can be changed, so that on a later occasion the input is tested against a corrected value. Similarly, a higher order homeostat may be imposed over this TOTE unit, facilitating or blocking the "operate" order according to complex internal or external constraints. This higher order *ss* may be an anticipatory function, as when the cook looks at his pantry and foresees a serious problem if supplies are not restored.

*Transferability of an Arousal System.* There is not likely to be serious objection to the development so far: that a discrepancy-detecting mechanism exists in the human organism and that this triggers a generalized arousal system. The atomistic level of analysis stays close to empirical data. The OR, biological homeostats, and even dissonance studies are compatible with the principles stated.

Neurologically, it is assumed that this *d*-mechanism is a CNS function, probably limbic (see below). This mechanism can be conditioned, just as muscle action can be linked to new stimuli. Biofeedback research demonstrates that CNS activation patterns can be conditioned to external cues or to internal "volitions." Thus, organismic development involves the establishment of new *ss* and the linkage of the new *ss* to the *d* mechanism. It is convenient to refer to this process as one of "coopting" the *d* mechanism in the service of the new steady state, just as an arm movement may serve to obtain food or to indicate religious devotion.

Again, it may be noted that Sigmund Freud anticipated this notion of coopting a mechanism developed for one purpose to serve in a different cause. The infant shows defensive reflexes against noxious stimuli of external origin—shutting out the stimuli to avoid discomfort. The child may later adapt this device to defend against internal, instinct-based anxiety. He suggested that "we may be assisted by the idea that a defense against an unwelcome internal process will be modeled upon a defense adopted against an external stimulus, that the ego wards off internal and external dangers alike along identical lines" (1954, vol. 20, pp. 22–23).

The relevance of this to our present discussion is simple and obvious. The organism must cope with disturbances of essential steady states. Pribram (1962) comments that Freud had to abandon his simple postulate of inertia (homeostasis) because of disturbances arising from endogenous stimulation. "The organism is consequently obliged," Pribram writes on behalf of Freud, "to abandon the original trend toward a reduction of its level of excitation to zero. Organisms must . . . learn to tolerate a store of excitation sufficient to meet the demands of the specific actions necessary to relieve endogenous stimulation. . . . When the organism reacts so as to maximally reduce excitation, this is called a *primary process.*[7] When the level of excitation is maintained relatively constant through a complex set of interactions with the environment . . . this is called a *secondary process*'' (p. 444, italics in original).

This can be said in somewhat more straightforward terminology. Every organism is capable of expectancy learning. The infant may respond to hunger by imaging or hallucinating the breast, but this does not reduce the inner disturbance. The arrival of the needed supplies is signaled by certain visual, auditory, and tactual cues. The infant learns that the hallucinated gratifications are not effectual, but that the appearance of these exteroceptive signals will be followed by release of tension. Thus he learns that discrepancies can be tolerated for longer periods of time, and that a quest for certain significant cues may help him in shortening the time interval.

This mechanism would conform to Freud's hypothesis that ''the ego wards off internal and external dangers alike along identical lines.'' All that is involved is that certain cortical, ANS, glandular, and muscular response sequences, originally triggered by intense stimuli, by stimuli deviating from AL, or by stimuli reporting discrepancies to hypothalamic homeostats, now become attached to perceived discrepancies in the external environment.

*Expectation of Disequilibrium.* Repeated, intense, or persistent disturbances of biological *ss* will lead to the formation of an expectancy of discrepancy ($E_d$). This expectancy can trigger effort to forestall the disturbance of *ss.* At this point the arousal mechanism has been integrated into a new, more complex, outward-oriented defense system. The organism does not simply restore preexisting *ss;* it also establishes new conditions (stores of food, protective walls) which are defended as instrumental to homeostasis. This is no more than Freud's assertion that anxiety can motivate actions designed to prevent other events, such as physical injury or social humiliation.

$E_d$ is a motivational function which looks forward in time. Thus, the organism mobilizes energy when a signal portends the onset of disturbance of equilibrium. Behavior calculated to prevent *d* from developing has been called forestalling behavior (Stagner, 1951). Most of adult human behavior is an immediate function of $E_d$ rather than of *d,* at least insofar as *d* refers to the biologically established homeostats.

Pribram (1971) defines the same phenomenon in terms of ''biasing the homeostats.'' He says, ''You are prepared to eat, predisposed to eat, by the workings of the homeostatic mechanism. But this mechanism is tuned by

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[7] It is tempting to identify Freud's primary process with proximal incentives, i.e., with input changes which directly reduce *d,* and secondary process with distal incentives, inputs which promise reduction of *d.* However, Freud's terms have also come to imply thought and fantasy processes which extend far beyond the scope of this discussion.

prior experience" (p. 198). He suggests the analogy of a higher order thermostat for home heating, one which has a sensor outside the house. It can report atmospheric temperature changes so that protective actions can be taken before the house chills. In terms of our diagram in Figure 2 (p. 129), this is a function of cortical efferents operating to bias the homeostat in anticipation of a threatening or rewarding situation.

This kind of neural mechanism is adequate to cope with the research on cognitive control of pain, hunger, and other biological states. It is now generally agreed that the brain has devices for controlling its own inputs. "Filters" or "gating mechanisms" are activated by cortical systems. There is even recent evidence that the human endocrine system can produce an opiatelike hormone ("enkephalin") which has the same action in blocking limbic pain receptors as the known drugs (Kosterlitz & Hughes, 1975). Since such secretions can also come under cortical control, the organism has a method for protecting itself to some degree from the disrupting effects of chronic, intractable pain or from pain which the individual deliberately decides to tolerate, as in resistance to torture. Self-definitions of situations and social comparison processes thus may operate through arousal or inhibition of homeostatic mechanisms to bring out effortful behavior.

*Relevance of Biofeedback.* Biofeedback research provides strong empirical support for discrepancy theory. Not only can heart rate be conditioned classically to an external CS; it can also be conditioned as an operant, with the person monitoring his own heartbeat and learning to increase or decrease it at will (Schwartz, 1973). Various confirmed manipulations indicate that peripheral skin temperature, alpha and theta rhythms of the EEG, and even the relative dominance of right and left cerebral hemispheres can be incorporated into complex response systems which we colloquially call "voluntary action."

The voluntary control of these inaccessible mechanisms is accomplished, of course, by providing exteroceptive feedback, visual or auditory, so that the person can detect when he is changing in the desired direction, and "do more of whatever that was." At this moment we do not have a suitable biofeedback procedure for incorporating the discrepancy-detecting or the energy-mobilizing mechanism into voluntary sequences. However, the wide range of biofeedback phenomena already well established should convince any skeptic that the possibility exists.

*The Final Common Path* (*fcp*). The mechanism which is linked to new stimuli in the manner just described is the *fcp,* the sole and unique energy-arousal mechanism. It is analogous to the final common path for effector responses identified by Sherrington. If *fcp* is preempted by one *d,* that motive will dominate behavior and others will be blocked.

Observations on the hierarchy of motives, and on the substitution of symbolic for physical goals, require an assumption of this kind. If there were not a single mechanism for arousal, it would be possible—indeed, probable—that they would cancel, or summate. The weight of the evidence points to alternation of different motives in control of the *fcp* rather than any additive effect.

The *fcp* hypothesis is supported by Valenstein, Cox, and Kakolewski (1968), who studied activities induced by direct brain stimulation (ESB). They found that in many cases the specific activity changed in accordance with available external objects. For example, the ESB which induced eating might also elicit gnawing if only chunks of wood were available, or drinking if only water were in the cage. An analogous finding is that of Coons and Cruce (1968). They used satiated rats, and stimulated the lateral hypothalamus, the "center" producing eating. They write that "a satiated animal will repeatedly press a bar delivering ESLH [electrical stimulation of lateral hypothalamus] slightly greater than the hunger threshold when food is immediately available next to the bar, but not otherwise. At higher currents the presence of food is not essential" (p. 1118). In other words, the sight of food summated with a weak electrical stimulus to induce eating; but if stronger stimulation were applied, the animal would *seek out* food to act out the compulsive behavior. A plausible interpretation, then, is that the effect of ESB is to induce arousal; if the stimulation is weak, it must be reinforced by the sight of food, whereas stronger stimulation will compel the animal to search for food.

*Specific and Nonspecific Components.* The principle of *fcp* cannot stand without modification. Weil (1974) summarizes neurological evidence to show that each homeostat has efferents which function to trigger specific reflexes, and others to limbic system and cortex, of a nonspecific character.

The specific components are those which have been designated in the category of "static homeostasis" (Stagner & Solley, 1970). Thus, activation of the receptor which reports a rise in body temperature above normal leads immediately to dilation of peripheral blood vessels, sweating, and other reflexes to speed heat loss. Conversely, the osmotic pressure homeostat, if triggered by lack of water, will inhibit sweating to reduce water loss. These specific responses were designated as manifestations of a process called "static" homeostasis because they functioned as in a closed system and operated solely to restore the disturbed *ss.*

Obviously, psychological problems center around the more complex aspects of homeostasis operating in an open system. If the reflexes do not succeed in restoring normal temperature within a limited time, the organism will "voluntarily" seek a cooler environment; a human being may remove some clothing, go swimming, or turn on the air conditioner. Clearly this is not a closed system and the new *ss* may be quite different from the original. These effects are functions of the *nonspecific* components of arousal.

The two major nonspecific efferents from homeostats are to the ANS and the cortex. The cortex receives the informational content (most of this probably from the peripheral afferents) and combines this with the nonspecific evidence of a large or persistent *d*. This may eventuate in more detailed scanning of the distal environment, or it may lead to scanning of engrams for memories of past experiences which may be helpful. Coping strategies result from this process.

The ANS activates bodily mechanisms such as the cardiac, vascular, respiratory, and digestive systems, and the endocrine glands, as these may be helpful to sustained physical exertion. The liver releases glycogen, the adrenals and pituitary supply hormones which may have survival value, and so on.

This brings us back to a problem cited earlier: the problem of indices of arousal. Just as Anderson's (1938) work demonstrated inconsistencies in the overt manifestations of effort, so the research of J. I. Lacey (1950, 1967) destroys the assumption of a single integrated manifestation of arousal of visceral mechanisms. Heart rate changes and blood pressure changes, for example, have often been cited as indices of arousal, but they may give divergent results in a specific person in a specific situation.

*The Arousal Continuum.* The assumption that arousal is general and nonspecific runs through the discussions of motivation by many authors. Neurophysiological support is found in the work of Lindsley (1952, 1957) on EEG, in which he identified a continuum from coma or deep sleep to alertness or high arousal. This conceptualization agrees with "common sense" or the intuitive belief that the organism acts as a whole; it is aroused to a measurable degree, and this is true for the entire organism.

It also seems undebatable that energy, once mobilized, is expended by the total organism. Tension can to some extent be channeled into physical exertion, or it can "drain away" over a period of time.[8] But these phenomena are not limited to the specific organ system involved in the mobilization phenomenon.

The assumption of a unidimensional continuum of arousal fits closely with the empirical fact that the individual has only a finite amount of energy to dispense, and that diverting effort from one activity to another is the only available way of coping with a new threat to survival. The resources, in

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[8] It is no accident that most tranquilizers are also muscle-relaxants. Discrepancy leads to arousal and to muscle tension; kinesthetic feedback maintains the arousal state. Relaxation breaks the cycle and permits the *fcp* to be preempted by other inputs.

other words, are limited and the person cannot pursue prestige while also pursuing food.

In opposition to the assumption of a unified arousal state, Lacey (1967) marshals extensive evidence as to the specificity of *arousal indices.* He shows that EEG activation (shift from slow, high-amplitude to fast, low-amplitude waves) often does not agree with indices of ANS arousal. Heart rate, blood pressure, and GSR often correlate at a discouragingly low level. He points to a number of studies which demonstrate dissociation of the various response mechanisms that have been assumed to change together as the arousal level changes. From this evidence Lacey concludes that, contrary to the predictions of various writers, "electrocortical arousal, autonomic arousal, and behavioral arousal may be considered to be *different forms* of arousal, each complex in itself" (1967, p. 15, italics in original).

How can motivation theory deal with this problem? Lacey seems to want to keep the concept of arousal in his own analysis. He suggests that the arousal state may derive from an integrated mechanism which begins to differentiate early in life. Perhaps, he proposes, "differential fractionation" (DF) of this once-unified system accounts for the results.

Once more it seems that we must postulate a "hypothetical pure case" of generalized arousal, with all mechanisms agreeing on the level of arousal. Then we begin to search for modulating conditions which may help us to explain or to predict the specificity developing among the different subsystems.

Obviously, there may be differences among subsystems with respect to thresholds of activation, ease of conditionability, temporal oscillations, and the like. The effect of a given afferent input on the CNS will depend to a considerable extent on the state of the CNS when stimulated. This would lead to the implication that the once-unified pattern of nonspecific arousal begins to differentiate or fractionate from birth on. Some response components are intensified or exaggerated, while others are minimized or blocked. Thus, medium to low intercorrelations of ANS indices merely indicate the long-continued process of differential fractionation.

Ax (1967), commenting on Lacey's summary of research, agrees with the conclusion that indices are inconsistent, but declines to be distressed by this fact. He notes, for example, that his own pioneer work on the physiological differentiation of fear and anger in terms of ANS arousal patterns would have been impossible if all ANS manifestations correlated closely. *Differential patterning can occur only if fractionation has already gone forward.* This, in the context presented by Ax, means that specific elements from the cognitive evaluation of the environment (danger one must escape, or danger one must fight) and from the nonspecific arousal system become integrated into an identifiable pattern of fear or anger.

*Activation and Energy Mobilization.* Cortical "activation" is not in itself a form of energy mobilization. Activation need not involve any increase in the *amount of energy* either input to or output from the cortex. The change from high-amplitude slow waves (alpha) to low-amplitude fast waves (beta) may not involve any net increase in energy utilization in the cortex proper. The changes are in tempo and pattern of firing, and a change in the distribution of activity, plus slow-potential changes which may be involved in the speed with which cortical mechanisms process incoming afferents.

This must be juxtaposed to the fact that level of energy expenditure of the total organism varies widely, going up sharply in a period of activation and dropping during relaxation. Coincident with cortical activation and ANS arousal we observe muscular tension and/or contraction as the organism prepares and acts. Glands and visceral systems also use up a substantial amount of energy. Thus the function of the CNS is to mediate energy mobilization, but in the effector systems, not in the nervous system itself.

It seems probable, therefore, that cortical activation identifies a situation in which afferent inputs to the cortex are especially likely to trigger effector patterns, both muscular and glandular. The ANS arousal will also have initiated glandular changes to provide chemical energy. The fact that CNS and ANS are partially independent simply allows for wider variation in the means of coping with specific experiences, hence, with estimates of threat and probability of goal-achievement for the future.

*Directional Fractionation (DF) and Personality.* Even in middle childhood the individual seems to have established his own unique pattern of cortical, ANS, glandular, and visceral changes in stress situations. This pattern defines a personality in terms of modes of energy mobilization. One is impressed by the statement (Lacey & Lacey, 1958, pp. 72–73) that each person exhibits "idiosyncratic patterns of autonomic activity. . . . These patterns of response tend to be reproduced from one stressor-episode to another." In at least some persons this DF becomes so well generalized that it can be associated with a measurable trait of personality. Lazarus and Alfert (1964) used as a stressor a film with some rather gruesome sequences. Some subjects, called "repressors," showed a high level of physiological arousal, but denied that they were disturbed. Others, called "sensitizers," verbalized a high level of distress but their physiological indices showed low arousal.

This difference between persons who are conscious of arousal but show little visceral change, and persons who respond vigorously without being aware, is compatible with Lacey's categorization of "environmental detection" and "environmental rejection," with Pribram's notion that the CNS may "open up" to the environment or block afferents in order to scan memory engrams more intensively, and with the popular concepts of perceptual vigilance and perceptual defense. It is highly probable that such individual differences will prove relevant to energy mobilization, for example, with respect to the relative weighting of recorded *ss* and input, as these might affect coping. Emphasis on *i*, for example, may be associated with ease of modifiability of *ss* in reducing the value of *d*. Heavy weight on the past (previous value of *ss*) would imply rigidity and a demand that the prior status be restored in detail—a feature of the obsessive personality. It is also possible that individuals developing "detection" or "rejection" as a systematic and consistent pattern will be found to differ with respect to focusing of energy, random diffusion of energy, deflection of energy into visceral churning, speed of reduction of *d*, and other dimensions of personality. Much further research is needed in this area.

## V

Any theory which proposes to give a central place to discrepancy-reduction must somehow deal with *affectivity* as an energy-mobilizing variable. Many critics of homeostasis have pointed to aspects of human behavior which seem to be motivated simply by a search for pleasure or avoidance of pain. The task for the theorist is that of harmonizing the two explanatory principles. (It is worthy of note that the hedonist likewise has a problem, since he must explain the energizing aspect of biological *d;* in addition, he has the problem of relating affectivity to visceral and energizing processes.)

Most discrepancies are experienced as unpleasant. However, the AL experimentation indicates that very small values of *d* may be described as pleasant. This is especially clear for *ss* such as temperature, glucose, and sensory inputs of low survival significance. Habituation seems generally to result in some buildup of unpleasant affectivity, and consequently, any change (e.g., in a monotonous sound) may evoke a feeling of mild pleasure.

Similarly, reduction of *d* is almost invariably pleasant. The removal of irritating internal stimuli such as those for hunger, thirst, fatigue, insufficient oxygen, or excessive heat or cold, will predictably be described as pleasant. And the buildup of these discrepancies will, as soon as they become conscious, yield judgments of unpleasure.

Because of these observations, homeostatic theorists have proposed that affectivity be considered as a secondary energizing state, triggered by more fundamental processes at the level of *d*. The data from neurophysiology (Weil, 1974) give partial support to that idea. Weil shows that the homeostats have efferents going to the systems evoking conscious experiences of pleasure and unpleasure.

Against this view is posed the evidence indicating that the search for pleasure and avoidance of pain can release energy independent of any homeostatic or social *d.* Western philosophy and psychology offer a long history of affective versions of motivation. From Aristotle to Descartes and Bentham, hedonism has been the major theme.[9] Consequently, the development of motivation theory degenerated into debates over quantitative versus qualitative hedonism, over short-term versus long-term summation of pleasures and pains, and over egoistic versus altruistic pleasures. Freud, in a very real sense, terminated these debates by demonstrating that conscious pleasure and conscious pain were only a part, and perhaps a minor part, of human dynamics. His stress on unconscious motivation is entirely compatible with a biological approach to the problem; hedonism, however, lost most of its credibility at this time.

Hedonism in revised forms must still be recognized as a view to be considered. Young's researches on palatability as a form of motivation cannot be ignored. Young and Chaplin (1945) showed that rats, given a choice of sucrose or casein, continued to choose sucrose even after fairly severe protein starvation had been induced. If homeostatic *d* had been dominant, casein would have been preferred to sugar. They found, however, that casein was chosen when the sucrose was physically distant enough that the animal could, so to speak, ignore it and eat enough of the casein to experience beneficial consequences. After that, the animals showed a preference for casein.

More sophisticated views of motivation have been proposed which are essentially elaborations of the hedonistic approach. McClelland, for example, combines the role of discrepancy with that of affect. "*A motive is the redintegration by a cue of a change in an affective situation*" (McClelland, Atkinson, Clark, & Lowell, 1953, p. 28, italics in original). This resembles Helson's conceptualization of the relevance of AL to motivation; a person will not mobilize energy in response to stimulation which merely duplicates prior input. There must be a change in stimulation. McClelland et al. say that one exerts effort to attain a condition which is perceived as *more* pleasurable or *less* painful than the present. Obviously, this fits our concept of *d* as the unifying thread in a diversity of views about motivation.

McClelland et al. are not clear as to the interaction of their two factors, discrepancy and affect. The theory is described as affective, but many passages in the book ascribe a major role to discrepancy: "Certain

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[9] Actually, homeostatic theory also can trace an ancient lineage, to Alcmaeon of Crotona (c. 550 BC), who espoused an equilibrium theory of physical and mental health and assumed the existence of automatic corrective mechanisms within the organism. A good history of these terms is given by P. T. Young (1961).

stimuli or situations involving discrepancies between expectation (adaptation level) and perception are sources of primary, unlearned affect" (1953, p. 28). Here, as in others of their 12 hypotheses about motivation (pp. 42–66), discrepancy plays a primary and affect a derivative role.

Homeostatic theory has tried to cope with the problem of affective motivation by treating hedonic tone as a dependent variable, which then may function as an intervening variable in later behavior. Experience indicates that most goal-objects which are sought for homeostatic reasons also are judged by humans to be pleasant, and animals behave in a manner to suggest the same conclusion. Conversely, environmental conditions operating to disrupt *ss* or to increase *d* are experienced as unpleasant.

On the other hand, the data clearly confirm that in many cases pleasure-seeking behavior occurs without any detectable discrepancy of a homeostatic character, as in drug reactions and—without suggesting any linkage—in the esthetic enjoyment of music or visual art. Even when a person knows full well that a euphoria-inducing drug is homeostatically destructive, he often continues its usage. Thus, there are real conflicts between the two approaches.

An important component of a possible solution is represented in Figure 2. This diagram proposes that at birth the affective systems are subsidiary to the homeostatic system. In this condition the survival–pleasure relationship conforms to discrepancy theory. However, the mere existence of an affective system which can function independently opens the probability that it will differentiate and function independent of the *d*-mechanism. Thus, just as it has been argued earlier that this *d*-mechanism, or *fcp*, may be coopted for dealing with protection of *ss* such as property or ego-status, so it is now proposed that the affective system may become integrated into S-R units not involving any discrepancy. The fractionation of the pleasure system out of the total motivational system may thus be conceived as another example of Lacey's differential fractionation.

This argument can be supported by several lines of evidence. First, we note that countersurvival pleasure-seeking is rather rare in nature. The conflict studied by P. T. Young, between need and palatability, is a function of artificial or highly refined diets and may only indicate that natural selection and evolutionary mutation cannot keep up with man's technological ingenuity.

Second, the evidence is persuasive that AL does have an important relation to affectivity, and that this in turn fits the discrepancy analysis. The *d* concept is not indispensable here, but it is certainly appropriate.

Third, experimental evidence can be cited to support changes in discrepancy and affective value. Some 30 years ago it was believed that elevation of *d* reduced the threshold for appropriate substances. The work of

Meyer (1952) and other investigators casts doubt on this, although some of the "feedforward" studies do lend some support to the threshold notion. Probably the significant change is in the affective value of inputs when *d* is intense or prolonged. The outstanding experiment on this problem is that of Cabanac (1971), whose procedure included extensive taste tests on glucose solutions, determining for each of three subjects the concentration which was judged "unpleasantly sweet." The three then fasted to the point of a 10% loss in body weight. At this time the previously unpleasant solution was described by each person as "pleasant." This result cannot be explained by AL processes, since fasting would tend to reduce the expected glucose level and so widen the gustatory discrepancy induced by a strong concentration of glucose. One speculates, therefore, about a possible feedback loop from the liver to the hypothalamus by which a lowered glycogen level would trigger a change in the affective value (hence, dynamogenic value) of glucose input.

*Neural Mechanisms.* Neurological speculation has been avoided to this point because the most important considerations regarding motivation are behavioral. However, it seems appropriate at this time to indicate how the homeostatic mechanism can mesh with affective, dissonance, and social comparison theories of motivation by referring to recent neurophysiological explorations.

Major interest in this area was triggered by the remarkable work of Olds and Milner (1954), who succeeded in implanting electrodes in "the pleasure area" of a rat's brain. The animal worked so energetically for the electrical stimulation of this system that he eventually collapsed—though whether from exhaustion, hunger, or thirst is not clear. What is obvious is that the motive to obtain this stimulation was more potent than ordinary homeostatic discrepancies. The same prepotency holds with regard to sex; Carlsson and Larsson (1974) showed that male rats, faced with a choice between ESB of the pleasure system or a receptive female, unanimously chose the electrical source of gratification.[10] The advocate of a homeostatic or discrepancy theory then must find some way of harmonizing such observations with his theoretical predilections.

In a concise summary of anatomical and physiological research on mechanisms involved in motivation and emotion, Weil (1974) suggests that "pleasure" and "unpleasure" are based on limbic systems (not centers)

[10] The dominance of homeostasis over sex (which we may equate with pleasure, as Freud so often did) is confirmed by Johnston and Zahorik (1975). Using the technique of pairing a distinctive taste with visceral illness, they induced in male hamsters an aversion to the female sex attractant. On later tests these males avoided estrous females. Kuo (1967) demonstrated that male pups could be trained to drive other males away from receptive females, but not to mount these females themselves.

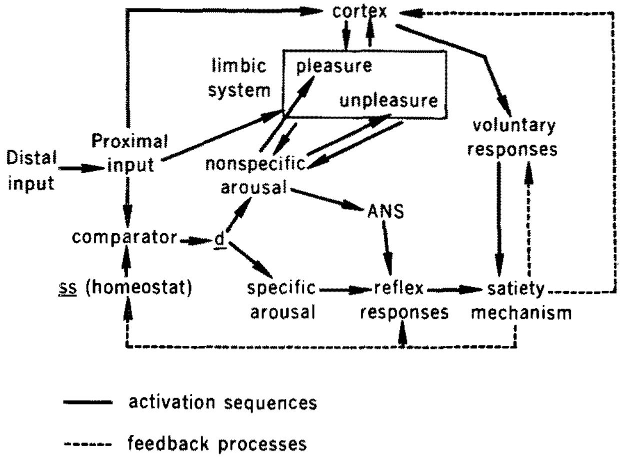

**Fig. 2.** Hypothetical relationships among the discrepancy-detecting mechanism, specific and nonspecific arousal, affectivity, and satiation. In this formulation, the *d* mechanism is the essential energy-mobilizing system. Steady states (*ss*) are recorded centrally and input (*i*) is automatically checked against *ss*. Arousal includes specific and nonspecific components; these may become fractionated and linked with varying external stimuli, as in fear and anger. Originally the affective systems are dominated by the *d* system, but through fractionation they may be activated independently and induce nonspecific arousal. The cortical representation of motivational states is primarily affective, although some stimulus inputs also go directly to the cortex. The satiety mechanism operates to lower the motivational level primarily through feedback to the *d* system.

activated by inputs from sensory channels and also from the ARAS (ascending reticular activating system). The affective systems are more clearly involved in behavioral outcomes, e.g., consummatory responses, than in the early phases of motivated action. Nonetheless, activation of either of these affective centers may also initiate energy mobilization; i.e., the occurrence of a stimulus input which has associative connections with either the pleasure or the unpleasure center can activate the dynamogenic center. This is indispensable because organisms frequently seek pleasure or avoid pain in the absence of any identifiable homeostatic imbalance. However, the system is integrated and, under normal conditions of life, the discrepancy sets off affectivity and action; the pursuit of affectivity (hedonism) becomes a major motivational consideration after some amount of learning has occurred.

There are three major arguments to support the view that the discrepancy system is primary and the affective system derivative: (1) Hedonism does not explain why biological mechanisms are triggered by a search for pleasure. We need a theory of motivation which explains energy mobilization in a biological framework. Whether man seeks food, sex, power, or salvation, the mechanisms employed are biological. A homeostatic theory relates these social motives to the biological response systems. (2) Homeostatic disturbances may initiate energy arousal without affective involvement, and, indeed, affective values are modified by homeostatic changes, as in the Cabanac study. (3) The logic of evolution seems to favor a homeostatic-discrepancy view. Hedonic motivation unrelated to biological need would activate much countersurvival behavior, a phenomenon rarely observed in subhuman species. Even in the human, much of the maladaptive behavior related to hedonic motives is related to the artificial conditions of modern life, such as concentrated drugs, nutrition-deficient foodstuffs, and the like.

*Speculations about Mechanisms.* Figure 2 proposes a conceptualization regarding the relationships among *d,* specific and nonspecific arousal, affectivity, ANS responses, and voluntary responses. The ingredients of this diagram represent the elements which seem to be common to a number of speculative analyses of the neural mechanisms underlying motivation and emotion. The only major omission is that no attempt has been made to incorporate those more complicated systems of integrated reflex and "voluntary" responses called fight, flight, freeze, feeding, and sex. While the evidence indicates that the crucial connections are in the amygdala, there is also ample evidence that these responses do not occur in well-organized form if thalamic and hypothalamic systems are damaged. In any event, this paper has not attempted to incorporate response systems in any significant fashion.

Figure 2 proposes that affective consequences of sensed *d* are most likely to follow from the nonspecific arousal of ARAS and hypothalamic systems. This would be in accordance with traditional homeostatic conceptions. But the diagram also makes allowance for the autonomous functioning of the affectivity system. There may be direct afferents from receptors to the affective organization, as in purely sensory pleasures related to color, sound, and like factors. There is also the major possibility that cortical systems activated by sensory afferents may trigger pleasure or unpleasure directly, as when one experiences pleasure upon hearing good news. (It is in this respect that the affective system may be coopted into complex operations not derived immediately from discrepancies. The mechanism diagrammed also allows for ideationally elicitied pleasure or unpleasure to activate ANS and glandular mechanisms.)

One further point may be added regarding Figure 2. Homeostatic theory requires a satiety mechanism, something which will feed back to shut off reflex and voluntary responses as, or even before, *d* is eliminated. The individual learns to estimate just how much of a goal-substance is required. Preloading the stomach with glucose reduces proportionally the amount of food eaten (McHugh, Moran, & Barton, 1975). An esophageal fistula which causes water to drop out before reaching the stomach indicates that dogs correctly estimate the amount needed to correct dehydration (Adolph, 1941). Some interest attaches to the question of generality or specificity: Does each *d* have its own satiety shutoff device, or is there a single mechanism which is triggered by different afferent inflows? The analysis presented here favors a single satiety mechanism which is tied in to the *fcp* for all motives, the general arousal system. Its inhibitory effect, then, is general and not specific. Antelman and Szechtman (1975) write, "Studies in recent years have demonstrated that peripherally applied stressful stimulation, for example, electric shock to various parts of a rat's body, can reliably induce aggression or copulatory behavior, or both, depending on stimulus conditions. We report here that a similar stimulus, such as tail pinch, induces eating in sated rats when food pellets are present" (p. 731). No one is likely to argue that a tail pinch is an adequate stimulus to the consummatory response of eating or even to the homeostat which initiates food seeking. Rather, this food pinch must affect the final common path, the general arousal mechanism, to modify responses to immediately present environmental stimuli. It probably operates to override the satiety mechanism and reinstate whatever consummatory response was most recently in progress.

The conclusion that the satiety mechanism functions as a portion of the general arousal system need not conflict with Maslow's oft-quoted assumption that man is continually active because satiation of one motive simply causes another to emerge and dominate the effector system. The satiety device would merely shut off whatever was in progress; it would perhaps in exceptional cases delay the onset of alternative motives, but no doubt for a brief time only.

## VI

While the problem of affective motivation presents the most challenging opposition to discrepancy theory, there are others which merit brief mention, if only to show that they can be dealt with in fairly simple fashion.

*Curiosity.* Many psychologists have asserted that motivation in the form of curiosity and exploratory behavior contradicts the homeostatic theory. This position is supported by the allegation that the individual is actually disrupting an equilibrium, not restoring it.

Some important observations are ignored by those who would postulate an innate "need" to explore. One is the research of John B. Watson, who found that a loud sound induced, not curiosity and exploration, but fear and avoidance. A *small* discrepancy from current sensory input does indeed induce alerting, limited arousal. If the modest stimulation continues, exploration is likely. But the magnitude of the discrepancy from expected input is a very important component of this relationship. Intense stimulation, which might be expected to induce even more curiosity, produces an escape response.

The work of Donald Hebb (1949), in which he found that very bizarre stimuli evoked fear and tension in chimpanzees, is another example of the weakness of curiosity as an innate motive. If the urge to explore strange phenomena is innately determined, and is triggered by "something unusual," then it should be even stronger as the stimulus appears stranger. Hebb's data suggest that, at least for our cousins, this is not true. It is also doubtful that young children spontaneously explore completely novel stimuli. As they grow and are exposed to fairy tales, TV and movie makeup, and the daily news, they may become somewhat habituated to the grotesque, and may widen their exploratory behavior. But the discrepancy principle seems to be operative for youngsters.

*Dangerous Pastimes.* Allport (1961) criticized homeostasis as an explanatory principle because, he alleged, many individuals deliberately engage in activities which disturb equilibrium and expose themselves to the threat of biological damage. He cited the explorer Amundsen, who eventually reached the South Pole, as an instance of a person who acted in a nonhomeostatic fashion.

It seems just as reasonable to say that Amundsen acted in a completely homeostatic fashion within an unusual, self-selected framework. Amundsen did not set off for the Antarctic with his summer underwear and a bag of fresh fruit. He obtained the best gear possible to help him survive, to ward off the threats to biological *ss* which, he correctly foresaw, would be omnipresent on his venture. Raup (1925) commented, with respect to a similar criticism of what he called "complacency" theory (an early version of homeostasis), that people seek challenges and take risks *which they believe they can overcome.* This is by no means the same as saying that the person is deliberately flouting the principle of homeostasis. It may be an example of misperception; the individual may underestimate the threats, or overestimate his own capacity, or be misled about his equipment. The fact remains that this kind of operation does not begin until the adventurer sees an acceptable chance of survival.

*Spontaneous Action.* Cofer and Appley (1964), after an extensive review of homeostatic theories and criticisms thereof, boil the objections down to three: "First, it is essentially negative in nature—that is, it nowhere appears to allow for spontaneous action, but conceives of systems only in terms of their response to disturbance. Second, its critics maintain that equilibration cannot adequately account for altruistic and creative behavior. Third, and conversely, it is not thought able to explain satisfactorily behaviors apparently directed at destruction of the very system(s) of which they are presumed to be a function" (p. 366).

The third of these has just been examined and rejected. The first, that homeostasis does not allow for spontaneous action, can likewise be refuted. We shall not argue that the organism is completely passive; metabolism is constantly going on; internal changes occur and activate CNS and ANS mechanisms. Consider, for example, the question of food intake. The neonate spends most of his time sleeping; he shows minimal spontaneous action. As metabolism proceeds, the glucose level drops and triggers a homeostat. Arousal is observed, with limb and trunk movements, vocalization, vascular changes, and other activities. Satiation leads to a cessation of activity as sleep supervenes.

With increasing age and maturation, less sleep is necessary. The interoceptive stimuli habituate. This may in itself become aversive; at least, it sensitizes the infant to variations in external stimuli. Sights, sounds, odors evoke arousal, and this facilitates the same movements formerly occurring with hunger. "Spontaneous" activity, in this framework, can be considered to be a function of inner arousal magnifying response to slight discrepancies in the external stimuli.

Low levels of stimulation are regularly associated, according to observers of infants, with *lack* of "spontaneous" activity. The syndrome, sometimes called "hospitalism," is characterized by passivity and lack of spontaneous movement. Hunt (1961), although he has often stressed the inner motivation of the infant toward spontaneous activity, has also conceded that in a low-stimulus environment, this spontaneity declines toward zero. Provence and Lipton (1962), reporting on infants in an institution with very little adult attention, wrote that the activity level was very low; "self-stimulating activities such as hand–foot, foot–mouth and genital play were extremely rare" (p. 119). Thus, it appears that the allegedly spontaneous activity of the human infant must be sustained by exteroceptive inputs or it disappears.

It is important to note that this insistence on the role of optimal stimulus input does not convert the baby to a *tabula rasa.* There are dozens, perhaps hundreds, of intervening variables which will modify and modulate these inputs and the responses which ensue. Each child quickly becomes a unique individual. But it is a uniqueness which expresses the child's style of coping with the external milieu; to cite Freud again, the organism must defend itself against these "powerful energies" which could destroy it.

The sensory deprivation research likewise need not be interpreted as favoring spontaneous activity needs. It is closely compatible with an AL discrepancy approach. The individual is adapted to (expects) a certain volume of sensory inputs. For the first hour or so, sensory isolation may be relaxing and pleasant. Long continued, it sets off anxiety and panic. These reactions are probably due to high arousal as *d* continues, plus excessive scanning of engrams in the absence of afferent impulses.[11]

*Altruistic Activity.* The remaining objection cited by Cofer and Appley relates to the inadequacy of homeostatic theory to explain the energy channeled into altruistic acts. Altruistic endeavors among adults are generally complex phenomena involving persons with whom the actor has some identification or affiliative relationship. Thus, parents often make sacrifices for their children, who are perceived as objects of affection and also as extensions of the parental ego; hence, as was argued earlier, the individual may mobilize energy to protect those aspects of his environment which are ego-involved. Labor union members may make sacrifices for their fellows, but this may reflect only an egocentric calculation that they may need help themselves one day. Similarly, soldiers make sacrifices for their nation. Again, the evidence seems to indicate that these are usually associated with danger to men close by, personally involved.

It is perfectly obvious that man has the *capacity* for altruistic behavior. It is not at all obvious that he has any instinctive *need* to behave in an altruistic manner. Rather, the empirical data suggest that altruism is likely to be based either on a mutual-defense concept (I protect you against threat; later you may protect me) or on the principle that one protects objects and persons identified with the ego.

## VII

*The Predictable World.* The basic commandment of homeostasis is: Control your environment or die. The theory of motivation sketched here does not limit itself to the constancy of the internal milieu; it must be extended, if it is to make any psychological sense whatever, to predicting change in the environment and controlling that change if it constitutes a threat. *Uncertainty means danger;* expectancy of threat becomes a major arousal factor.[12] The individual must be alert to any change in his environment; habituated stimuli elicit no response, but a discrepant input evokes

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[11] Boredom is affectively unpleasant, and also induces ANS arousal (London, Schubert, & Washburn, 1972). This arousal, or arousal induced by exteroceptive stimuli, may actually improve efficiency on a repetitive task (McBain, 1961).

[12] Man's "search for certainty" extends also to animals, as the *d* theory would predict. Preference for signaled shock as opposed to random shock is found in both rats and humans (cf. Badia, Suter, & Lewis, 1967). Preference for food obtained by lever-pressing may be interpreted as a need to feel in control of the environment.

OR, attending, tension, intensified responding. Infants may, and often do, suffer helplessly because their inner homeostatic mechanisms are inadequately developed and the external environment is not subject to control. This is the source of the basic anxiety and powerlessness stressed by Alfred Adler, Karen Horney, and Erich Fromm. The individual develops, as Woodworth once remarked, a need to perceive, a need to sense changes in his world so he can either control them or take protective action against them. The origins of perceptual constancy, object conservation, and other cognitive devices are to be found in this need to predict correctly the threats likely to appear in the outer world.

*The Condition of the Free Life.* When Claude Bernard (1859) wrote that "the constancy of the interior milieu is a condition of the free life," he may have meant free from the sea; the land-borne organism carried its chemical constancies with it in a bag of liquid. This liquid had to be protected if the organism were to survive. But it is also possible, as Cannon (1939) extrapolated, that the dynamic principle of homeostasis freed man from constant slavery to external threats—slavery because he had to be constantly on guard against these dangers. "With homeostatic devices... that keep essential bodily processes steady, we as individuals are free from such slavery—free to enter into agreeable relations with our fellows, free to enjoy beautiful things, to explore and understand the wonders of the world about us, to develop new ideas and interests, and to work and play..." (p. 323).

The thesis developed here has two major points: first, that Cannon is correct in asserting that homeostatic mechanisms are essential to the awareness, as well as the gratification, of what Maslow called "higher needs;" and second, that the discrepancy mechanism inherent in homeostasis is coopted by the organism in the structuring of aesthetic motives, curiosity motives, and stimulus-seeking motives. A discrepancy-reducing need is thus established as a unifying principle, running through all varieties of psychodynamics, and tying the social, cognitive, and aesthetic motives firmly to the biological mechanism which provides all of man's energy for whatever activities he elects to carry out.

The coercive power of homeostatic motives has long been recognized, and Bernard's famous dictum was anticipated by none other than Karl Marx. In one of his essays on human nature, Marx wrote that "people on the whole cannot be liberated so long as they are unable to obtain food and drink, shelter and clothing in adequate quality and quantity" (quoted by Easton & Guddat, 1967, p. 437).

It seems likely that Marx referred to substantially the same kind of liberation implied by Cannon, or by Maslow in his proposition that self-actualization is not possible until basic biological and safety needs have been gratified. Liberation in the political and economic sense implies, among other things, freedom to express oneself, freedom from arbitrary control by those who can restrict access to food and necessities, and freedom to engage in varied activities not harmful to others.

Some theorists have even found in homeostasis a paradigm for the greater contending forces about which men have speculated for many generations. An extreme version will be found in Barach (1974), who finds it possible to identify an analogy between the organismic balancing of metabolic needs and environmental pressures and the struggle between good and evil. The analysis offered here does not aim so high; it seeks only to establish the general principle that energy mobilization is governed by the discrepancy principle and that this provides for a conceptual reunification of motivation theories based on clinical, industrial, and experimental observations.

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