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CHAPTER I

GENERAL SYSTEMATIC PRINCIPLES

At the present time, psychology contains any number of empirically discovered "parts." There have been some attempts to order and systematize this knowledge. Nevertheless, psychology has few internal principles and still fewer principles which unify it with physics, chemistry, biology, and physiology.

This chapter is an attempt to explore some unifying principles which have been applied in physics and biology (Shannon & Weaver, 1949; Odum & Pinkerton, 1955; Bertalanffy, 1950; Bertalanffy, 1952; H. Jacobson, 1955). In the following chapter, an extension of these principles to individual functioning will be described. These principles, which make possible a broad theory of individual functioning, also make possible a unification of psychology with biology and physics. Collectively these principles comprise "system theory."

A system, says Allport, is "any recognizably delimited aggregate of dynamic elements that are in some way interconnected and interdependent and that continue to operate together according to certain laws and in such a way as to produce some characteristic total effect" (Allport, 1954, p. 469).

Within system theory there are two branches, "open" and "closed" system theory. In closed systems, no energy may enter or leave the system; in open systems energy may enter or leave, and hence many more equilibratory states are possible.

Both types of systems, as described by system theory, exhibit at least four characteristics: (a) they deal with energy exchanges expressed in "negentropy terms," (b) feedback is an important consideration, (c) dynamic equilibrium states, termed "steady states," are reached, and (d) several routes may lead to the same steady state, hence steady states may be "equifinal" (Cherry, 1952; Shannon & Weaver, 1949; Allport, 1954, ch. 18).

System theory deals with energy exchanges. The first attempts to deal with energy exchanges were attempts to generalize the second law of thermodynamics. According to this law, given an enclosed container with two compartments, a gas in each compartment at a different temperature, and an aperture between the compartments, the system of the gases in the two containers will "level off" to a common temperature.

The generalization showed the possibility of many intermediate states before reaching this common temperature. The same principle was reached by Shannon (1949) while investigating telephone networks. Shannon also contributed another way of looking at the mathematical formulation. He spoke of a decrease in the disorderly or random dispersion of energy, or the increase of "negentropy." When energies are ordered to perform a certain task, the orderliness can be mathematically specified. For instance, human sounds are reproduced when random energy is organized in a radio circuit.

Brillouin (1949; 1950) was probably the first to suggest that biology, physiology, and probably the social sciences could be placed in a systematic framework involving energy exchanges expressed in negentropy or communication theory terminology. Raymond (1950) generalized the negentropy equations.

Feedback mechanisms are devices which correct a machine when it functions at or outside of preset limits (McCullock, 1950; Weiner, 1949). A governor on a car which prevents excessive speed is such a mechanism. In electronic amplifiers a portion of the output is fed back to the input to make the amplifier a more stable electrical system. In system theory, feedback is one way of maintaining the system.

Steady states are "time independent states where the system remains constant as a whole and in its phases, though there is a continuous flow of the component materials" (Bertalanffy, 1950, p. 24). These are the dynamic equilibrium states. It is possible to go from one steady state to another, but the route to a particular steady state is irreversible in time.

Steady states are also equifinal. That is to say, a given steady state may be reached within a system through numerous ways. If a steady state performs like some other steady state, and if its negentropy is the same, it is by definition a similar steady state, although the second state may be a resultant of different forces.

Ashby in his book, Design for a Brain (1954), has presented a unique demonstration of a closed system. The system is composed of two electrical mechanical devices. Each device "adjusts" itself in response to alterations in the components of the second device. The alterations induced in either device are both minor and major. That is, there are adjustments on the part of the second device to maintain a steady state and also greater adjustments which establish a new steady state. The principles Ashby demonstrates with these devices are those for a physical, closed, but complex system. It is a closed system in that at no time is there a gain in energy in the system.

In contrast to Ashby's devices, living systems, from cells to complete organisms, are best described in open system terms. For example, the colloidal system in the cell "strives" to maintain the cell. Nutrient materials are absorbed through the cell membrane and the cell grows in the attempt to maintain itself. A system in which it is possible to gain energy through metabolism is an open system.

A review of both open and closed system theory is presented by Allport (1954, pp. 467-530). The best description and summary of open system applications in biology is that of Bertalanffy (1950; 1952).

Metabolism, says Bertalanffy (1952, p. 131), is the process by which the steady state is maintained. Irritability, motility, and autonomous activities (heart beat, breathing) appear as smaller wave processes superimposed on the metabolic wave. Growth, development, senescence, and death are expressions of slow changes in the steady state.

Bertalanffy differs from other writers in this area in stating that a number of biological phenomena are best understood in terms of a direct interaction of the components rather than in cybernetic feedback loops. This difference can be resolved only with further work in applying the open system model to living organisms.

Summarizing the generalizations in biology made possible by open system theory, Bertalanffy states:

> The theory has shed new light on many problems of which only the most important ones shall be enumerated here: the absolute body-size and the explanation and calculation of growth in time of animals; the

> principle of the constancy of cell-size; the cyclic growth of mammals; the course of regenerative growth; the verification of the theory by measurement of the absorbing surfaces; the statement of different metabolic types of animals with respect to the dependence of respiration on body-size and in correlation with corresponding growth types as deduced by the theory; the correlation between intensity of metabolism and body-size with respect to sex differences; the calculation of the intensity of catabolism of building materials from the growth curves of animals and verification of the calculated values of independent physiological experiments; the application of the theory to ecological problems, such as the dependence of growth on temperature (Bergmann's rule) and to geographical variation; the peculiarities of the human growth curve and their significance for the somatic and mental development in man (Bertalanffy, 1952, p. 137).

Unfortunately, the mathematical developments of open system theory are not far advanced. It would appear that the further application of open system theory may come through the broadened concept of "homeostasis." Some question concerning the applicability to new areas of concepts invented to explain phenomena in one area can always be raised. They must be resolved in terms of usefulness in understanding the new areas to which they are applied.

According to a review of homeostasis by Dempsey (1951), it was Claude Bernard, a famous physiologist, who remarked on the small limits within which the body chemistry must be maintained for life. Cannon, says Dempsey, was able to demonstrate some of the mechanisms whereby functioning within these limits was maintained. One section of the review of homeostasis by Dempsey is entitled, "Homeostatic

Aspects of the Intellectual Functions." Cannon, himself, did not hesitate to apply the homeostatic notion to the social world.

This analogous broadening of the homeostatic notion has continued. Recently Emerson (1954) has presented a paper on homeostasis as a unifying principle in organic, social, and ethical evolution. Krech (1950) has suggested that all dynamic systems are open neurological systems. Odum and Pinkerton (1955) have concerned themselves with optimum efficiency in such systems, while H. Jacobson (1955) has investigated the meaning of open-system theory for the origin of life and species reproduction.

The work of Zipf (1948), some parts of which are admittedly speculative, deserves mention at this point. Zipf presents a number of ingenious analogies to show that human social behavior is lawful. He attempts to test the notion that individuals expend "least effort" or "least work" in accomplishing their tasks.

Taking language as an example, the force of "unification," the use of as few words as possible, should operate to decrease the number of different words used and to increase the frequency of usage. On the other hand, the force of "diversification," the use of many words to attain the different shades of meaning, should operate to increase the number of different words used and to decrease the average frequency of usage. The operation of these two opposing forces in a lawful manner is taken as evidence of a movement towards least effort in language.

Evidence for this principle was obtained by studying the frequency of the 29,899 different words out of a total of 260,430 running words in James Joyce's Ulysses. The plot of the rank of word frequency versus frequency of usage yields an equilateral hyperbola which can be described mathematically by an harmonic series.

The size of words and the spacing between equal-sized words makes it appear as though in effective speech, the words are chosen "with a frequency that is inversely proportional to the work involved . . . [and also so that there is an] . . . even distribution of work over time" (Zipf, 1948, p. 51).

Zipf then turns to investigate language development, personality, mentation, the social problems of human geography, stable national equilibria, and unstable international and intranational equilibria.

While it is interesting to note that such social behaviors are lawful, there is much to be desired in the precise definition of least effort and in deriving this principle from system theory. Odum and Pinkerton propose that "systems perform at an optimum efficiency for maximum power output, which is always less than maximum efficiency" (Odum & Pinkerton, 1955, p. 232). The meaning of "efficiency" as here used should not necessarily carry any implications of desirability (Odum & Pinkerton, 1955, p. 343).

In psychology, Freeman's Energetics of Human Behavior (1948), which will be discussed later, is based on a concept of homeostasis broadened to fit psychology. Stagner (1951; 1954) has written on homeostatic principles in personality and produced an elementary textbook espousing them (Stagner, 1952).

There are of course criticisms of homeostasis. Richards (1953) views homeostasis as failing to explain pathologies. Maze objects to homeostasis on teleological grounds. He says, "the notion arises, that organisms possess a special kind of causality, namely, a teleological causality, so that the part-processes within an organism are determined not by the nature of those parts (since they have no distinct nature), but by the effect which is to be produced by them in the organism as a whole" (Maze, 1953, p. 407).

A few notations can be made in answer to Richard's statements. If one postulates the rules by which a system comes to a state of homeostasis, and the system then is disturbed, as in a pathological state, a new homeostatic level, a new steady state, arises. It has long been recognized that psychological novelty may arise, but that these cases are already incorporated in the theoretical structure. That theory is said to be best which predicts most new effects which are observationally checked. The failure, if any, of the homeostatic processes operate in the case of pathologies.

In summary thus far, the analogous application of the homeostatic concept to areas other than physiology, while leaving much to be desired, opens up a new avenue of systematization. The area of human endeavor through which this systematization is presently being attempted is that of open system theory.

It should be noted from the foregoing that a conceptual framework of the broadest type for the systematization of psychology as related to the biology of organisms exists. The principles of homeostasis may be subsumed in such a system.

The possibilities of applying system theory to various areas of endeavor have been aptly summarized by Raymond:

> The development of a modern theory of communication has led to an interpretation of the process of information transfer in terms of the creation of negative entropy in places where information is used to direct physical or chemical processes. A consideration of the effects of information storage and information transfer on physical, chemical, biological, psychological, and sociological systems, both open and closed, may help in understanding and predicting many of the aspects of our universe (Raymond, 1950, p. 278).

CHAPTER II

OPEN SYSTEM IN PSYCHOLOGY

G. L. Freeman's The Energetics of Human Behavior is an attempt to present psychology in terms of open system theory. When a living organism is viewed, many levels of operation are noted, as for example: the cellular level, the organ system level, the response level, and finally the complete organism. In each case there is an interaction of bodily parts or mechanisms which deal with energy transformation. That is, in order to function, each of these systems transforms energy (Freeman, 1948, p. 34).

It seems reasonable that a description of energy exchange within an organic system, and between systems, might help in understanding how an organism functions. The response system level would appear to be of primary concern to psychology. Evidence obtained from research on the motor theories of mental activity led Freeman to his concept of neuromuscular homeostasis as a possible explanation of response system functioning.

Darwin in his treatise on the emotions gave impetus to the motor theories of mental activities (Freeman, 1948,

p. 12). That is, various emotional expressions on the human face were due to inherited muscular similarities in men and the other animals. The James-Lange theory simply added a feedback from the periphery of the body to the central nervous system, so that specific emotions might be identified by the peripheral patterns.

It remained for Ribot, a student of Charcot's, to note that human functioning was more complex than a peripheral-central bifurcation would explain. Ribot, relying on his instruments and on his powers of observation, postulated at least three types of motor responses when a stimulus was presented: circulatory, postural, and sense organ adjustment (Freeman, 1948, p. 12). This was stated in his theory of attention.

The question remained as to whether the stimulus induced the adjustments that Ribot noted or whether they were previously present. Féré, another student of Charcot's, realized that the function of the stimulus was to trigger or liberate energy (Freeman, 1948, p. 13). Hence, the amount of energy liberated becomes a function of ongoing processes and their organization rather than a function of the stimulus energy.

Unfortunately, this theory of organization was reduced by its opponents into a peripheral view. The opponents, among them Müller, Schumann, Myers, Von Kries, Titchener, and most recently, Mowrer, have claimed that peripheral activity is simply neural overflow from the central nervous system.

The most outstanding single piece of evidence that the peripheral process is more closely linked to the central nervous system than the centralists allege is that reported by Jacobson:

> The left arm of a graduate student at the University of Chicago had been amputated above the elbow-joint at about the age of 8 years. He said that he could imagine doing anything with his left hand that he could do with his right. This assertion would harmonize with our results if it meant that upon imagining acts with his left hand he merely visualizes or verbalizes the action; but not if it meant that he could imagine acts with the lost hand fully in the same physiological manner as normal Ss.
>
> In brief, the results with this S show that when he imagines bending the missing left hand, there generally occurs action-potentials from the stump-biceps muscle as well as action-potentials from the muscles that flex the right hand. In other words, when this S engages in mental activity concerning his left hand, certain muscles contract; but these, for example in imagined flexion, instead of being merely the muscles that flex the left hand, as in intact S, are in the stump of the upper arm, or in the intact arm, or in both places. S was not informed as to the purpose or methods of the investigation. It was therefore of striking interest, when, after he had evidently engaged in subjective observation during a number of tests, he suddenly volunteered that he desired to correct his original statement that "he can imagine doing anything with his left hand that he does with his right." He now stated that when he does something with his right hand the left seems in imagination to duplicate the performance, going through the same experience. But he never has experiences of his left hand's performing any act independently of the right. He adds, "My imagination of bending the left hand is but a shadow--a duplicate of what the right hand is imagined to perform." In short, his original statement is ambiguous and he corrects it. He can imagine doing anything with his left hand that his right hand does, but only under one condition; namely, that the right hand, at the moment of the imagination, actually engages in that same act or is

> imagined to engage in that same act. No independent imagination, such as exists for intact Ss, exists for this S's left hand (E. Jacobson, 1932, p. 689).

Max (1935) reported that activity was present in the arms and fingers of deaf mutes in thirty out of thirty-three instances of dreaming.

Jacobson carried out a series of experiments intended to teach persons how to relax. His summary of his own and other pertinent research lends further support to the linkage of peripheral and central phenomena:

> When the subject, lying relaxed with eyelids closed, engages in mental activity such as imagination or recollection, contraction (commonly slight and fleeting) occurs in specific muscles. Evidence is thus afforded that the physiology of mental activity is not confined to closed circuits within the brain but that muscular regions participate. . . . During visual imagination or recollection the muscles that move the eyes contract, as if the subject is looking at the imagined object. . . . During what psychologists term "inner speech," muscles in the tongue and lips contract as if to say the words in swift and abbreviated manner. . . . During imagination or recollection of muscular acts or of matters that involve such an act on the part of the subject, contraction occurs in some of the muscle-fibers which would engage in the actual performance of the act. Exceptions are noted when visualization occurs alone, as is characteristic in some subjects. . . . During a particular mental activity the muscles of a quietly lying subject, trained to relax, remain inactive, as a rule, excepting those specifically engaged as above stated. . . . Electrical records, along with subjective reports, indicate that, during general progressive muscular relaxation, imagery and thinking processes dwindle and disappear. . . . Relaxation of the specific muscular contractions present during a particular mental activity brings about the disappearance of that activity. This is accomplished by trained subjects in periods sometimes varying from about 0.2 to 0.5 seconds as measured by action-potentials (E. Jacobson, 1938, pp. 344-345).

However, central "reductionism" still exists. Mowrer, Rayman, and Bliss (1940) have reported an experiment to support the central locus of set. They instructed subjects to give a reaction when either a visual or auditory stimulus was presented. Since the latency period was longer for this condition than for either stimulus alone, they concluded that their experiment furnished evidence that set was centrally mediated.

Freeman (1940) attempted a reply to this experiment in which he pointed to many organ sets other than a single response set. However, Davis' view is, perhaps, the most psychologically mature:

> To seek the "essence" of set either in the periphery or in a central locus would, therefore, be a mis-directed endeavor. Similarly, the characterization of the peripheral components of set as mere overflow seems to be verbal legerdemain for unduly limiting the field of investigation (Davis, 1946, p. 402).

In psychology, energy ordinarily has meant some very loosely defined, mysterious entity. Hence, one reads about "psychic energy," "libidinous energy," and perhaps even of the "elan vital" or "creative energy." The energy Freeman speaks of is physical energy, derived from food intake. As physical energy, it is measurable by physical means.

From Freeman's standpoint, "total behavior dynamics is the study of an energy system undergoing change" (Freeman, 1948, p. 37). The limits of this energy system are the skin of the organism (Freeman, 1948, p. 35). At one time, a stimulus applied to a system may cause a specific response; at another time the response may seem not to occur. Whether a specifically patterned response or a more diffuse response occurs depends on the flux, the pattern of flow, of energy.

The preceding paragraph should not be interpreted to mean that there is no stability to energy exchange systems. On the contrary, systems tend to maintain themselves in their functions. Each energy system in the energy hierarchy carries on its metabolism and also makes up for the disintegratory effects produced by disturbances external to it. In brief, the energy systems strive mechanically to maintain the dynamic equilibrium or constant state.

Cannon used the term homeostasis to describe this type of physiological functioning at the organismic level. Freeman has broadened this homeostatic concept. In general, for Freeman, at the organismic level, there are two major systems, the digestive-circulatory, and the neuromuscular system. The functions of these two systems are complementary. Either system, under stimulation beyond certain limits, disrupts the other, which being displaced, institutes behavior to produce alleviation of the disturbance.

The digestive-circulatory system may be visualized as an open-ended tube, one end for food intake and the other for the expulsion of waste-products. Around this open-ended tube is the ring or doughnut of the neuromuscular system. As stimuli impinge on the doughnut ring, the organism adjusts at the expense of the "coupling" between the two major systems. In other words, there may be changes in the rate at which energy is taken from the digestive-circulatory system.

These changes occur as changes in the metabolism of the organism. Disruptive changes are more catabolic; restorative changes are more anabolic. When these two changes are equalized, an equilibrium level is again established.

In general, stimulation from within or outside the skin displaces the organism's equilibrium. Reactions are made in order to remove the irritant stimulus or to reach a new steady state in which the stimulant no longer functions or is incorporated into the steady state.

Occasionally, the return process is initiated only after a certain point is reached and is quantitatively independent of the amount of displacement. More often, however, the process of return is proportional throughout to the amount of displacement. Furthermore, to aid these changes, there are large energy reserves built into the organism. For example, there are various food storage depots which can be called upon to help restore the steady state.

The study of organismic energy exchanges is not the study of food or oxygen consumption _per se_. It is the study of the use of these energies, the patternings of energy transformations under various stimulations. If, under stimulation, a subject's response is increased, he is said to be operating on a higher energy level than previously.

Many of the studies of outer responses have fallen short in that there has been a failure to note that a response differs depending upon the internal energy level of the individual from which the response was made. When this principle is taken into account, says Freeman, the major areas of behavior can be explained in terms of neuromuscular homeostasis.

Obviously, any description of energy exchanges within the organism depends on the method of measurement. The indicator must be stable, that is, reliable, and also sensitive enough to indicate significant changes. Calorimetry, oxygen consumption, total insensible weight loss, palmar skin resistance, blood pressure, and muscle tension have been used.

The indicator of greatest promise for total energy exchanges is the electrodermal resistance (EDR) of the palms. This measure correlates highly with oxygen consumption and is little influenced by changes in room temperature and humidity (Freeman & Giffin, 1939). Furthermore the EDR summates both sympathetic and parasymphetic effects, reflects induced muscular tension (Freeman & Pathman, 1942; Freeman & Simpson, 1938), and is sensitive to new stimulus demands on the organism (Freeman & Giese, 1940). In addition it reflects changes quickly.

In outline, when a subject is placed in the EDR apparatus, his resting level, the basal steady state level from which changes are to be measured, is first ascertained.

Next, a displacing stimulus is introduced. The homeostatic behavior which follows can be described in terms of three phases: (a) the arousal phase, the displacement from the resting level reflecting the internal mobilization of energy to meet the situation, (b) the response phase reflecting the channeling of energy to meet the situation, and (c) the recovery phase reflecting the return of the subject to either the original resting level or some other steady state level from which he will operate to meet subsequent stimulation.

The measurements for each of these phases are in terms of relative levels because the size of the response is a function of the energy background. Energy residuals, if not discharged, remain in the system. Stimulus effects are known to depend on the amount of time since a heavy meal, the amount of exercise, the amount of sleep, and also the individual's habitual operating level (Freeman, 1948, p. 68).

A rule-of-thumb procedure for obtaining a basal level for studying the homeostatic cycle is to allow the subject 15 to 30 minutes of quiet rest. The resting level is not an average of EDR measurements during this time, but rather a selected level of high resistance which the subject maintains for at least five minutes towards the end of the period. Obviously, the experimenter's judgment and experience are called into play in setting this level.

When displacing stimuli, such as drugs or induced tensions, are then presented, varying responses are obtained, depending upon the patterning of energy already in the system and the specificity of the patternings of this energy. This patterning is termed the "focal background" (Freeman, 1948, p. 66).

Specific responses to stimuli may be heightened or disappear altogether depending on previous residual energy increments. Facilitation aspects are complex. "The exact range of facilitating effect depends upon individual differences in habitual energy level, character of task, or complexity of response required for specific equilibrium of a displacing stimulus, the amount, locus, and timing of the induced tension process" (Freeman, 1948, p. 71).

Theoretically, at least, arousal and discharge underlie every response to stimulation. In the first phase, arousal exceeds discharge and this phase is referred to as the "arousal" or "mobilization" phase. During the "work" or "response" phase, arousal and discharge are ordinarly about evenly balanced. Finally, in the third or "recovery" phase, discharge exceeds arousal.

Now, if an overt response fails to remove the excitation aroused by the stimulus, it continues to rearouse and to maintain the total disequilibrium. Such responses are said to be "specifically nonadaptive." When the subject is "blocked," observers have reported an increase in such nonspecific behaviors as tics, rate of foot tapping, and gum chewing (Freeman, 1948, p. 90). In tension experiments the response the experimenter is watching for may be completely dispelled by these seemingly irrelevant responses. If a specific task is set for the subject, the process of "focusing" on the task and eliminating these irrelevant responses can be demonstrated (Freeman, 1948, p. 92).

Incidentally, the more the subject is confined the more irrelevant behaviors manifest themselves in any of the remaining sensory-motor channels left to him. For instance, Freeman reports an increase of fluctuations of a reversible staircase under these conditions (Freeman, 1948, p. 78). Increased fantasy production as a result of frustration in the real world is also not alien in principle (Freeman, 1948, p. 119).

A graph of the relationship between response output (amount, strength, etc.) and degree of energy mobilization, with the former as the ordinate and the latter the abscissa, is roughly bell shaped. Maximum response is obtained ordinarily at something less than maximum energy mobilization. The energy level at which this response maximum occurs is called the "optimum" energy level. At levels beyond this point, performance deteriorates because the organism not only must try to maintain the performance but must handle the excess aroused energy as well. This condition is known as "overmobilization."

Depending on the organism and its habits, the task, the standards for minimally acceptable performance, and many other such factors, there is a degree of overmobilization which is critical. Freeman designates this as a "plimsoll mark" (Freeman, 1939). Beyond this point one or more of several things happen which tend to displace the organism even further--that is, the conditions for a "runaway" are set up. The organism may break down, either structurally or functionally. Performance may fail and stop or "snowball" to a collapse. In any case, the organism's organization for the task quickly deteriorates in a way which the organism apparently is incapable of stopping.

Other labels in psychology for this point might be frustration-tolerance, limit of adjustive capacity, and psychiatric danger zone. The point itself is a function of the way in which the individual recovers from previous stimulation. Some individuals discharge almost completely in a short time, others tend to carry and accumulate residuals.

These residuals may be disadvantageous to the individual in two ways. First, the energy spent in keeping the residuals under control weakens the individual so that his plimsoll mark is lowered to start with. Second, the presence of the residuals interferes with the performance so that the maximum performance level is reduced, thus requiring more energy to maintain even a sub-optimal performance level.

The organismic energy system and those factors which affect the measurement of it have been described. Beneath the special concepts there is present the interaction and the play of anabolic and catabolic processes. On the behavioral side, the effective use of one's energy depends on: (a) diversification, the variety of outlets available on stimulation, (b) the specificity of outlets, adaptive and nonadaptive, (c) supplementation, the energy resources and reserves, (d) the reactivation resources, the discharge or carry-over of residuals, and (e) moderation since the most effective equilibratory responses are made in the central range of operation.

Persons who seem to have little energy resources, those who appear constantly to be "living on nerves," high tension levels, and those who are unable to sleep due to improper discharge of the tensions of the day are common enough.

What has been said concerning irritable stimulation can be said inversely of satisfaction and feelings of accomplishment.

A large part of psychology is contained under the headings of motivation, learning, and personality. Freeman attempts an explanation of these areas in terms of principles of homeostatic behavior (Freeman, 1948, chs. 5-9).

Under "motivation" Freeman describes the interofective (autonomic) nervous system and the exterofective (cerebrospinal) nervous system. Primary needs such as food, water, and sex arouse the interofective system. If the readjustment cannot be made by the interofective system, the feedback-heightened tensions arouse the exteroceptive system. Thus the exteroceptive system becomes a slave of the interofective system and the first line defender of the essential "steady states." A greater sensitization to the needed materials is an expression of the internal need.

In human social living, in the world of ideals and aspirations, Freeman sees an attempt to maintain bodily constancy, a psychosomatic equilibrium. Personal and culturally instilled habits are learned in an attempt to maintain this constancy.

Such notions as "least effort," "minimal energy expenditure," and "efficiency," where applied to an organism, mean something more complex than the usual physical denotation (cf. p. 7). The complex and sometimes devious functioning of the organism must be included in such a term. Similarly the history of the organism and its personal and culturally instilled habits must be included. These terms are not synonymous with simplification but are applied rather to existing complex behavior patterns.

Learning, according to Freeman, involves the disequilibration of the organism and re-equilibration with modification in the direction of minimal energy expenditure. Such efficiency in behavior depends on the reduction of background tensions and the focusing of tension in the system or organ most concerned.

The conditions of learning are contiguity, exercise, and effect. In energy terms, the contiguity is that of certain kinds of response residuals. Exercise increases the arousal level and the effect of success or failure feeds back neuromuscularly to continue the task until the tension reduction of success sets the memory trace. It is true that learning may arouse auxiliary tensions, but these have an outlet in performance and hence the learning stabilizes without some of the detrimental tensions.

These energy principles seem to lend meaning in learning to the conceptions of Guthrie and Thorndike. They place a physiological base under continguity and effect. But all of this can be subsumed under the more general theory of neuromuscular sets. Learning then becomes a study of organismic energy exchanges.

Nondiscriminatory or emotional behavior Freeman views as an overflow of motor discharge into outlets not specifically adaptive. When blocked, such reactions tend to spread further and may culminate in somatic emotional responses. This energy discharge pattern, if it remains, may become chronic if other more adaptive channels for discharge cannot be found.

On the other hand, discriminatory behavior such as thinking, perceiving, and imagining are viewed as cases dominated by neuromuscular sets with controlled narrow outlets for the set tensions. Such sets as previously noted (see pp. 11-13) cannot be described as either wholly central or peripheral.

Personality differentiation in energy terms has not been developed. Individuals who differ in terms of mobilization and discharge and who represent various combinations of these factors have not as yet been adequately described in personality terms. A good many suggestions and specific relations have been pointed out, but no clear pattern of any breadth has appeared yet.

CHAPTER III

GENERAL STATEMENT OF THE PROBLEMS

In Chapter One, system theory was described and Bertalanffy's ideas concerning open system theory, a generalization of the second law of thermodynamics which can describe the life process, was presented. In Chapter Two, the system of G. L. Freeman was presented as a broadened system of homeostasis and, therefore, an open energy system.

The following experiments are open system investigations whose purpose was to demonstrate and explore the relationship between certain types of behavior and changes in the metabolic processes of the individual. The general hypothesis is that degrees of arousal will change significantly with changes in the intensity of stimulation. The discharge and recovery phases will also be a function, at least in part, of the intensity of stimulation and of the adequacy of the response. In one sense, these experiments are five discrete tests of this more general hypothesis. In another sense, these experiments can be viewed as dealing with the motivational process: energizing and directing behavior.

Since energy may be dissipated in various nonadaptive ways during these experiments, obtaining an inclusive energy index is not an easy task (see pp. 19-20). Changes in task demand may appear in either EDR or performance changes, or both. Inasmuch as no provision was made in these experiments for tight control of one or the other (e.g. pacing of the task to control performance, it is necessary to substitute statistical control for experimental control. Either the EDR or the performance measure could be regressed. It was decided to regress or correct the EDR scores for the level of performance to obtain an energy index which would relate to the situational conditions of each experiment.

Experiment One dealt with the relationship of stress and the EDR. Under the highest degrees of stimulation the organism can no longer draw on its energy reserves. Further increases in mobilization lead to mental and emotional collapse (see p. 21).

It is questionable that really high levels of mobilization can ever be obtained in the laboratory. Obviously such a level must represent a threat to life. Nevertheless, very high degrees of mobilization can be obtained by what has been termed "stress testing." The idea of such testing is to drive the individual's EDR level beyond the plimsoll mark. The hypothesis for this experiment is that, under stress, the EDR will either continue to mount significantly or stay level while performance deteriorates significantly.

Experiment Two dealt with the relationship of EDR and shifts of set. Freeman applies the principles of homeostatic response to neuromuscular sets which are at times specific and at other times diffused and nonspecific. These sets come about through backlash action and show adaptation (Freeman, 1948, pp. 214, 232).

In this experiment the subject was required to perform arithmetic problems involving addition, subtraction, multiplication, and division, in blocks of similar operations and also in mixed blocks. If these operations are mediated by fairly specific sets, the mixed blocks should require more shifting of sets. This shifting of sets should be reflected in a greater energy mobilization until adaptation occurs. The hypothesis for Experiment Two, therefore, is that increased energy mobilization will be significantly different for the varying number of shifts in the task when the speed of performance is held constant or controlled statistically by regression.

Experiment Three dealt with compensatory energy arousal to overcome distractions. Unfortunately for experimental work, and perhaps fortunately in other respects, organisms learn to overcome distractions; they adapt. Neuromuscular focalization occurs. However, there are wide individual differences in performance due to the degree of focalization, previous training, backlash residuals, and habitual ways of handling this backlash (see pp. 19-20).

In studies of performance under distractions, some individuals decrease their level of performance, some individuals maintain their level of performance, and others increase their level of performance. The third experiment was an attempt to show that these variant responses under distractive conditions are related to the mobilization and discharge of energy. It is suspected that EDR and performance are covariant. The correction of the EDR measures by means of regression on the performance scores should permit the arousal index to vary significantly with degrees of distraction. The hypothesis for this experiment is that there will be significant changes in the arousal index due to degrees of distraction when performance is held constant or controlled statistically by regression.

Experiment Four dealt with a personality problem. Freeman (1948, p. 98) has stated that the homeostatic principles apply to the higher levels of human functioning in such a way as to keep the ego intact. The ego is an organized group of attitudes dealing with the self, its capabilities, its projection into the future, its enhancement, and its maintenance in the face of frustration and threat.

Poor scholarship, the inability to do well in college, should be ego frustrating. In Experiment Four, the hypothesis is that degrees of ego-involvement, as judged by the subject and as judged by others, will show a significant relationship to degrees of energy arousal. This results from the fact that there are points of vulnerability in the more general diffuse ego set.

Making proper and acute judgments of ego-involvement is, of course, one aspect of the academic counselor's job. The purpose of Experiment Four was to demonstrate that judgments of degree of ego-involvement coincide with energy arousal levels. If this is so, then arousal levels can not only be used to diagnose troubled areas, but methods which make for therapeutic change may be specified in energy terms.

Experiment Five dealt with expectancy sets which involve little energy expenditure. In daily living, to meet various situations, the organism operates on the basis of expectancy sets (Freeman, 1948, p. 214). Walking down a new street, the next cross street is expected to be Elm Street. If this expectancy is not confirmed, behavior is disrupted as an attempt is made to discover why the expectancy was not fulfilled. On the other hand, if the next street is Elm, no disruption of behavior occurs. The expectancy set has been fulfilled. A mild state of satisfaction with regard to the expectancy may be present.

Expectancy sets are continually being either fulfilled or not fulfilled. In terms of the homeostatic cycle, the energy transformations should be different for fulfilled and non-fulfilled sets. The hypothesis for Experiment Five is that there will be significant changes in energy discharge due to fulfilled and non-fulfilled perceptual acts.

Consistent with the findings of Freeman and his co-workers (see p. 18), it is assumed that the EDR is a sufficiently sensitive indicator of energy change for these experimental purposes. Each experiment requires methodological controls such that the changes under study are not fully dissipated in responses beyond the recording devices used (see pp. 27-28).

CHAPTER IV

GENERAL APPARATUS AND PROCEDURE

In general, the procedure in these experiments is to relate psychological changes to changes in the organism's energy levels as measured by the electrodermal response (EDR). This measure, which refers to skin resistance levels and gross changes in level, is often confused with the small momentary reflex-like changes, the galvanic skin response (GSR) (Woodworth & Schlosberg, 1954, pp. 113-159). The early work on these latter potentials has been reviewed by Landis and Dewick (1929) and by Landis (1932). Interest in the relationship between these two measures arose when it was demonstrated that the magnitude of the GSR was dependent on the resistance level from which it originated.

Four of the experiments herein reported were performed by groups of graduate students during a course in motivation. The writer was the graduate assistant who designed them. All but the fifth, the perception experiment, had been performed, in modified form, in previous years. There was, therefore, a good possibility that this line of experimertation would be productive.

Low voltage, direct current, series type, rather than bridge type, circuits were used. In this type of circuit the subject is wired in series with a fixed resistor. Depending on the type of meter used in the specific experiment, either the voltage drops across the subject (read from a vacuum tube voltmeter) or the current flow through the subject (recorded by a General Electric ink-writing galvanometer) were converted to log resistance measures.

Vacuum tube voltmeters were read four times per minute for the stress, shift of set, and distraction experiments. A General Electric ink-writing galvanometer was used to record the data continuously for the ego-involvement experiment and the perception experiment as well as for recording the data of an additional control group for the distraction experiment.

The electrodes were of zinc embedded in plastic cups and both were worn in the palm of the non-preferred hand, leaving the opposite hand free for the task performance. EKG jelly made contact between the palm and the metal surface, approximately one inch square, of the electrodes. Each recording unit with its associated set of electrodes and switching arrangement for scale selection was fully calibrated throughout and beyond the range of resistances found in these studies.

Subjects were casually welcomed and the apparatus explained to them as similar to a part of the "lie-detector."

If fear of shock was voiced, the experimenter placed his hands across the battery to demonstrate its low voltage. The subject was connected to the apparatus and, since various relative resting levels were required, the remainder of the procedure was somewhat different for each experiment. Absolute resting levels are subject to so many unknown variables that little use can be made of them at present. Therefore relative levels and changes from these relative levels are measured.

However, the use of relative levels requires the specification of some reference condition which is reliable and which is the same from subject to subject. As reported earlier (see p. 19), Freeman proposed a condition of quiet but alert rest as a standard condition from which to specify the relative level.

Experience in the University of Oklahoma laboratories has indicated that for some subjects in some situations, Freeman's suggested conditions leave much to be desired. Consequently, an attempt was made to select such resting level conditions as might suit each experiment.

In many instances, a median or mean work level represents a more standard condition than a resting level would. The rest period, under these circumstances, provides an opportunity for the discharge of immediate residuals but does not provide the baseline for measurement. It should be noted that the resting level data are not lost and that a measure of energy mobilization is still obtainable. Only in the ego-involvement experiment was a resting level used as a base for computing the EDR change score. In the other experiments a median work level was employed as a base for computations.

The metric for expressing changes in EDR level has two problems associated with it. The first problem is that of finding a measure such that the changes in EDR are independent of the reference level from which they are measured. The most recent work on this problem is reported by Lacy (1947), Lacy and Siegal (1949), and Haggard (1949). The latter has shown that both log resistance and log conductance measures are additive, that is, independent of the reference level.

A second problem is to find a measure which not only is independent of the reference level but also meets the requirements of the most often used statistics. The analysis of variance technique requires normally distributed scores within the cells of the table, homogeneity of variance within cells, and independence of means and variances over the table. Unfortunately these statistical assumptions for change scores expressed in various transformations have not been studied. It is known, however, that the log resistance and log conductance measures lead to fairly normal distributions (Haggard, 1949). With regard to the homogeneity of variance assumption, Norton's study (Linquist, 1953, pp. 78-86) indicates that the analysis of variance results are only slightly affected by heterogeneity.

The usual procedure at the University of Oklahoma laboratory was to transform the resistance level measurements into log resistance scores and then to subtract from these scores a base level similarly expressed in log resistance terms. Such a log difference measure is a direct proportion measure. Therefore, the use of this measure implies directly that the meaning of a specified change in skin resistance is a simple direct function of the level from which the change occurred.

Since conductance is the reciprocal of resistance, some algebraic manipulation will show that the log conductance measure taken from a log conductance base level differs from the EDR measure described above only by a multiplier constant of minus one.

The drawback to the log resistance measure is the inverse relationship which holds between it and energy transformations. The higher the energy level, the lower the resistance, the lower the energy level, the higher the resistance. On the other hand, resistance is less confusing to psychology students, and more familiar, at least by analogy, than conductance.

With the hope of normally distributed scores and homogeneity within cells, experiments were designed to make use of the analyses of variance and covariance techniques. To control individual differences, "between subjects" and "within subjects" error terms were utilized where possible (Linquist, 1953, ch. 13). In certain of these experiments where differences from a work level were used, the between subjects sum of squares became zero since each subject's score was a deviation from his mean EDR score. In these cases, a separate analysis of variance for individual differences was performed preceding the calculation of EDR change scores.

CHAPTER V

STRESS AND THE ELECTRODERMAL RESPONSE

One of the ways of displacing the individual's basal EDR level is to induce muscular tensions. Usually in this type of investigation performance is related to the degree of induced tensions. Bills (1927) used a dynamometer to induce muscular tensions while his subjects performed various simple tasks. His results indicated more efficient performance under tension. Duffy (1932) recorded muscular tension for eighteen children while they tapped and performed a sensory discrimination. She found smoother tension records for those children who made higher sensory discrimination scores. Clites (1936) showed differences in muscular tension level associated with successful and nonsuccessful problem solving.

The results of these and other experiments (Freeman, 1948, pp. 69-73) seem to indicate that there is a complexity of factors involved in attempts to improve performance with induced tensions. That slow learners tend to benefit most from such conditions would appear to be the case (Freeman, 1948, p. 71). In other situations with other kinds of subjects tension has produced increased performance, deterioration in the quality of performance, or, in some instances, no change in performance.

Freeman has attempted to explain these different effects of tension by calling attention to some of the main factors involved. Tension effects on performance depend on the background conditions of the subject at the time of testing, that is, the number of open pathways available for the discharge of the tension (Freeman, 1938b). There are optimal supporting tensions for various types of performance (Freeman, 1938a). Not only are there optimal tensions, but different tension levels have different facilitative and inhibitory effects on performance (Freeman, 1933).

Freeman has summarized these effects: "The exact range of facilitating effect depends upon individual differences in habitual energy level, character of task, or complexity of response required for specific equilibrium of a displacing stimulus, and amount, locus, and timing of the induced tension process" (Freeman, 1948, p. 71). Controlling these conditions in an experimental investigation becomes an important problem.

It is generally agreed (see pp. 21-22) that the quality of performance under high tension levels deteriorates. As a matter of fact, the break-down of performance is used to define this heightened arousal level (Lazarus, Deese, & Osler, 1952).

As has been indicated previously (see pp. 27-28), it is probable that few laboratory situations, and indeed few life situations, are such as to drive the individual beyond the plimsoll mark. Experiments under stress testing are attempts to study the individual under high energy mobilization conditions (Freeman, 1945). The presence of stress in the situation is usually indicated by the disintegration of performance.

Freeman (1945), in an article concerning stress tests, points out that they are of two types: (a) conflicts of setting, where two antagonistic tendencies are set up, as in the well-known Luria technique, and (b) conflicts of defection where the assurance of one's ability is destroyed by failure. Freeman suggests that conflicts of defection or threat to the total organism be employed. Freeman and Katzoff (1942) suggest that conflicts involving motor tasks are more effective than verbally induced conflicts.

Lazarus, Deese, and Osler (1952), presenting a review of "stress testing," indicate that there is little, if any, agreement between researchers on how to induce stress or what to use as an effective performance measure.

This experiment, therefore, was set up following the suggestions of Freeman. The behavioral task selected was learning a complicated T-maze. When the subject appeared to have success within his grasp, an alley near the end of the maze was blocked. It was expected that the ability to learn the maze could be so structured as to make failure a very ego-hurting experience. It was hypothesized that, under the stress of failure in this maze situation, the energy level of the individual would continue to rise while performance deteriorated.

Method

The subjects for this experiment were twenty-one undergraduate students at the University of Oklahoma. They were welcomed casually to the laboratory and the EDR apparatus was explained to them as a kind of lie-detector. They were shown a T-maze similar to the one which they were expected to learn while blindfolded.

As part of the experiment, it was suggested to the subject that the ability to learn a maze was highly related to intelligence and hence to the ability necessary to obtain good grades in college. It was hoped that these instructions would motivate him so that a failure experience would be deeply felt.

The electrical resistance was recorded by means of a series circuit involving a 45-volt battery, the subject, a 47,000-ohm resistor, and a vacuum tube voltmeter. The voltmeter was read four times per minute.

Time and error scores per subject per trial were recorded. When the subject showed evidence of learning the maze, he was told that he was doing fine, and a barrier was inserted in a passageway fairly close to the end of the maze. On the trial involving the barrier he was told he did very poorly. This block was then removed and he was permitted to continue learning the maze. Insertion of the barrier was repeated once more, and then the subject was allowed to complete learning the maze to a criterion of three successive correct trials.

The resistance scores were converted to log resistance scores, and the subject's over-all median work level score was subtracted from the average per trial to obtain EDR scores for this investigation.

Results and Discussion

It became evident during the experiment that the subjects failed to become involved in the task and little or no stress was produced. To demonstrate this failure, the changes in the EDR across the barrier were correlated with the changes in the number of errors across these same barriers. These date are presented in Table 22 of the Appendix. The results are indicated in Table 1.

It should be noted that not one of the correlation coefficients reaches the .05 level of significance. Hence the hypothesis that any of these coefficients is significantly different from zero is rejected. If stress had been present in appreciable degree, some or all of these correlations should have been significant.

Table 1

Coefficients of Correlation between Changes in Error Scores and EDR Difference Scores Across the Barriers

Barrier	Correlation Coefficient	Degrees of Freedom (N - 2)	p
Barrier 1	-.11	19	> .70
Barrier 2	-.09	19	> .70
Barrier 1 and 2	-.09	40	> .60
Barrier with greatest EDR decrease	-.33	19	> .20

Where did the experiment go wrong? There are, of course, many factors, but it is clear that these factors operated in the experimental situation in such a way as to preclude a test of the hypothesis. The hypothesis stated that under stress the EDR will either continue to mount significantly or stay level while performance deteriorates significantly (see p. 28). Clearly, little if any stress was produced in the subjects.

To some extent, the failure of the experimental situation is a comment on the failure to convince subjects that a simple task such as maze learning is a fair index of intelligence. Certainly, the individual subject knew approximately his relative standing in the academic area and the kinds of measures on which his standing had been based.

Therefore, the instructions coming from inexperienced, non-prestige persons may have aided in the failure of the situation to produce a greater degree of stress. It can not be claimed that the maze learning task was itself too contrived or inherently a poor task choice. There is evidence to indicate that anxiety is related to maze learning performance (Matarazzo, Ulett, & Saslow, 1955). Perhaps the choice of subjects should have been limited to those who were having academic difficulties.

Certainly, this experiment is an uncomplicated, simple, yet important test of homeostatic principles under stress. It is suggested that a repetition of this experiment by a high-prestige, experienced experimenter using subjects who are in academic difficulty might succeed.

CHAPTER VI

SHIFTS OF SET AND THE ELECTRODERMAL RESPONSE

Dashiell (1941) has called attention to "set" as a neglected fourth dimension of psychological research. He pointed out that the term was ambiguous and had a long history stemming from early reaction-time studies.

Terms which have been used in lieu of set are attitude, readiness, orientation, expectancy, determining tendency, predisposition, einstellung, temporary preparation, organic disposition, excitation background, anticipatory reaction, preparatory adjustment, postural response, and some form of perseveration.

This list is far from complete, and Gibson (1941), in his critical review, lists many more concepts analogous to set. However, he concludes that there is little in common in these various usages and that "the controversies can not be resolved until psychologists come to grips with the experimental analysis of phenomena like attitude, set, intention, and expectation" (Gibson, 1941, p. 811). Dashiell, on the other hand, at least makes an attempt towards semantic clarity of the concept by claiming that set refers to a differential readiness and some form of conscious or unconscious perseveration. For him, set is part of the organization of the behavior hierarchy (Dashiell, 1940, p. 299).

Freeman (1931; 1939) and Dashiell (1928, pp. 275-276; 1937, pp. 339-340) espouse a neuromuscular theory of set. They feel that set is mediated by postural adjustments and by the interplay of neuromuscular patterns of stimulation, sensory and motor. Both these men make much of the tonic, the diffuse, slow, longer-lasting postural reactions as a "substratum" for the quick, brief, localized phasic reactions.

The present experiment, conceived in its broadest terms, is an attempt to relate shifts of set to bodily energy changes. These energy changes are to be measured by changes in the skin resistance levels, the EDR. However, since EDR and performance are covariant (see pp. 27-28) the EDR scores will be regressed on the performance measure.

Attitudes of university students toward mathematics makes it ideal material for obtaining EDR responses. If mathematical problems induce varying subjective estimates of difficulty, or muscular tension, or both, changes in the motor adjustments should lead to changes in EDR.

More direct evidence that the EDR is sensitive to arithmetical work is demonstrated in the experiment of Sears. Using easy and difficult sets of addition problems, he concluded: "The fact that amplitude of psychogalvanic reaction is consistently related to changes in speed and difficulty of one type of mental work seems quite clearly established" (Sears, 1933, p. 60).

The method of inducing shifts of set was suggested by an experiment reported by Dashiell (1928; 1937). He reported greater time and error scores for subjects who worked problems involving the mixed operations of addition, subtraction, division, and multiplication as contrasted to the same problems presented in blocks of similar operation.

Jersild (1927), using addition and multiplication problems, could not obtain evidence for very great increases in the time-error scores due to shifts. He did not make use of all four mathematical operations nor of a measure of effort.

Therefore, it would seem plausible that as arithmetic problems are solved in increasingly mixed sets of operations, the EDR scores regressed on the performance measure should show significant increases in energy arousal.

Method

The subjects for this experiment were twenty volunteers from an elementary psychology class of the University of Oklahoma. They were welcomed to the laboratory casually and the apparatus explained as being similar to a lie-detector. When they were reassured concerning the impossibility of shock in the apparatus, the two cup electrodes were placed on the non-preferred hand, and they were asked to relax.

The electrodes were wired in a series circuit similar to that used in the stress experiment (see p. 42). Resistance readings were read at the rate of four per minute during the experiment.

Subjects were randomly assigned to one of two task orders, ABC or CBA. Sheet A contained twenty-four problems per column, each column calling for only one kind of mathematical operation (addition, subtraction, multiplication, or division). There were three shifts of operation on Sheet A. Sheet B was composed of the same problems arranged in smaller groups of similar operation problems and contained a total of thirty-two shifts. Sheet C contained the same problems again but was even more mixed than Sheet B and contained forty-eight shifts. Two orders were necessary to counterbalance practice, habituation, and fatigue effects.

After fifteen minutes of relaxation, the subject was requested to perform the problems as quickly but as accurately as he could. He was permitted to correct mistakes but only by striking out the incorrect answer (not erasing it) and writing the correct answer. No review or re-checking was permitted. A ten minute relaxation period was given between sheets to allow residual tensions to decrease.

The resistance readings were converted to log resistance readings, and the median score per sheet was taken as the resistance level for the sheet. To obtain a reference level, the medians were averaged to obtain an average working level for each subject, and deviations from each subject's mean work level were computed for each subject for each sheet. A constant of two hundred was added to the deviation scores to make them all positive. It should be emphasized that the addition of the constant represents a linear transformation of log EDR change scores. It should be recalled, as has been previously stated (see pp. 36-37), that high numerical log resistance scores mean low arousal. Similarly, a high deviation score (with this constant added) means low arousal.

For the performance data, the time and error scores per sheet were combined into a corrected time score by penalizing the subject one ninety-sixth of his total time for each error. Because there were ninety-six problems per sheet, this scheme added the average time per problem to his score for each error. To parallel the EDR scores for a covariance analysis, deviations around each subject's mean were computed. A constant of one hundred was added to these deviation scores to make them all positive.

This investigation was designed so that a two-part analysis of covariance could be performed. The sheets were presented in the order <u>ABC</u> and also in a second order <u>CBA</u> to counterbalance learning, practice, and habituation effects. Taking deviation scores from each subject's mean has the effect of reducing the variance within each order and between the two orders to zero. To make a test of differences between orders, each subject's mean was retained for a separate analysis. These scores are labelled "Individual Difference Means" in the tabular presentations.

Results and Discussion

The basic EDR data for this investigation are presented in Table 23 of the Appendix, that for the corrected time-error scores in Table 24 of the Appendix.

Tables 2 and 3 summarize the analysis of the individual differences EDR data as previously explained. Orders ABC and CBA do not differ significantly. The F value of 2.78 for 1 and 18 degrees of freedom, yielded a probability of less than .20 (Linquist, 1953, p. 42). The variances within the two orders were homogenous, F equaled 2.07 and yielded a probability of more than .05 for Hartley's test (Walker & Lev, 1953, pp. 462-463).

It can be seen from Tables 4 and 5, for individual differences in time score, that the ABC and CBA order means, 325.8 and 305.4, differ significantly with a probability of less than .05 for the F value of 4.69. The F value for the within-groups homogeneity test was 1.22, which, with a probability of more than .05, is not significant (Walker & Lev, 1953, pp. 462-463).

Table 2

Means and Estimated Standard Deviations for the EDR Individual Difference Means for Shifts of Set

	Order	
	ABC	CBA
Mean	4191.1*	4077.6
Est. S. D.	122.9	176.8

*Log resistance scores times 1,000.

Table 3

Analysis of Variance for the EDR Individual Difference Means for Shifts of Set

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	*F*	*P*
Total	481,688.60*	19			
Orders	64,411.30	1	64,411.30	2.78	>.20
Error	417,277.30	18	23,182.07		

*Log resistance scores times 1,000.

Table 4.

Means and Estimated Standard Deviations for the Corrected Time Score Individual Difference Means for Shifts of Set

	Order	
	ABC	CBA
Mean	325.8*	305.4
Est. S. D.	80.1	89.0

*Corrected time scores in seconds.

Table 5

Analysis of Variance for the Corrected Time Score Individual Difference Means for Shifts of Set

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F	P
Total	162,652.80*	19			
Orders	33,640.80	1	33,640.80	4.69	<.05
Error	129,012.00	18	7,167.33		

*Corrected time scores plus 100.

Tables 6 and 7 present the deviation means and estimated standard deviations for the log EDR and corrected time scores. A test of homogeneity of variance for the EDR yielded an F of 12.1, which is significant at the .01 level (Walker & Lev, 1953, pp. 462-463). Similarly, the F value for the test of homogeneity of variance for the corrected time scores was 18.2. A value of 12.1 represents the .01 level, so that a value of 18.2 is highly significant.

In addition to the homogeneity of variance tests, within-groups correlation plots were drawn in an attempt to check on linearity and within-groups regression. Although the N was small, the plot suggested a nonlinear relationship. Despite these violations of the assumptions of covariance, such an analysis was performed (Linquist, 1953, ch. 14) and is summarized in Table 8.

It should be noted that the analysis of covariance yields .05 levels of significance for both the sheets and sheets x orders variables. Regression of the EDR scores on the performance measure adds the sheets variable as significant, although neither variable is significant in terms of the corrected time scores.

The means for each order for the EDR deviation and corrected time deviation scores from Tables 6 and 7 have been plotted in Figure 1. Since low arousal means a negative EDR deviation score, the EDR scale to the right of each figure has been oriented to run from low to high arousal. The

Table 6

Means and Estimated Standard Deviations for the Log EDR Deviation Scores for Shifts of Set

Order		Sheet A	Sheet B	Sheet C
<u>ABC</u>	Mean	-14.1*	15.6	- 1.5
	Est. S. D.	74.9	57.9	45.8
<u>CBA</u>	Mean	-43.4	- 4.2	47.6
	Est. S. D.	10.2	21.5	42.2
Mean Total		-28.8	5.7	23.1

*Log EDR deviation scores times 1,000.

Table 7

Means and Estimated Standard Deviations for the Corrected Time Deviation Scores for Shifts of Set

Order		Sheet A	Sheet B	Sheet C
<u>ABC</u>	Mean	2.3	7.6	- 9.9
	Est. S. D.	20.5	13.8	15.5
<u>CBA</u>	Mean	5.2	- 7.5	2.3
	Est. S. D.	54.1	19.3	58.8
Mean Total		3.8	0.1	- 3.8

*Corrected time deviation scores.

Table 8

Analyses of Variance and Covariance for the EDR Deviation Scores and the Corrected Time Deviation Scores for Shifts of Set

Source	Degrees of Freedom	EDR Sum of Squares	Variance Estimate	F	P	Time Sum of Squares	Variance Estimate	F	P
Total	59	175,288.00*				71,032.00**			
Between Subjects	19	0.00				0.00			
Orders	1	0.00				0.00			
Error	18	0.00				0.00			
Within Subjects	40	175,288.00				71,032.00			
Sheets	2	27,807.00	13,903.55	3.87	$<.05$	570.10	285.55	.15	$>.20$
Sheets x Orders	2	18,306.70	9,153.35	2.55	$<.10$	1,926.40	963.20	.51	$>.20$
Error	36	129,588.17	3,588.17			68,535.50	1,903.76		

Source	Cross Products Sum of Squares	Adjusted EDR Sum of Squares	Adjusted Degrees of Freedom	Regressed Variance Estimate	F	P
Within Subjects	-28,174.00					
Sheets	3,902.35	24,517.63	2	12,258.82	3.64	$<.05$
Sheets x Orders	4,065.15	21,617.26	2	10,808.63	3.21	$<.05$
Error	-28,011.20	117,725.72	35	3,363.59		

*Log EDR deviation scores times 1,000 plus 200.

**Corrected time deviation scores in seconds plus 100.

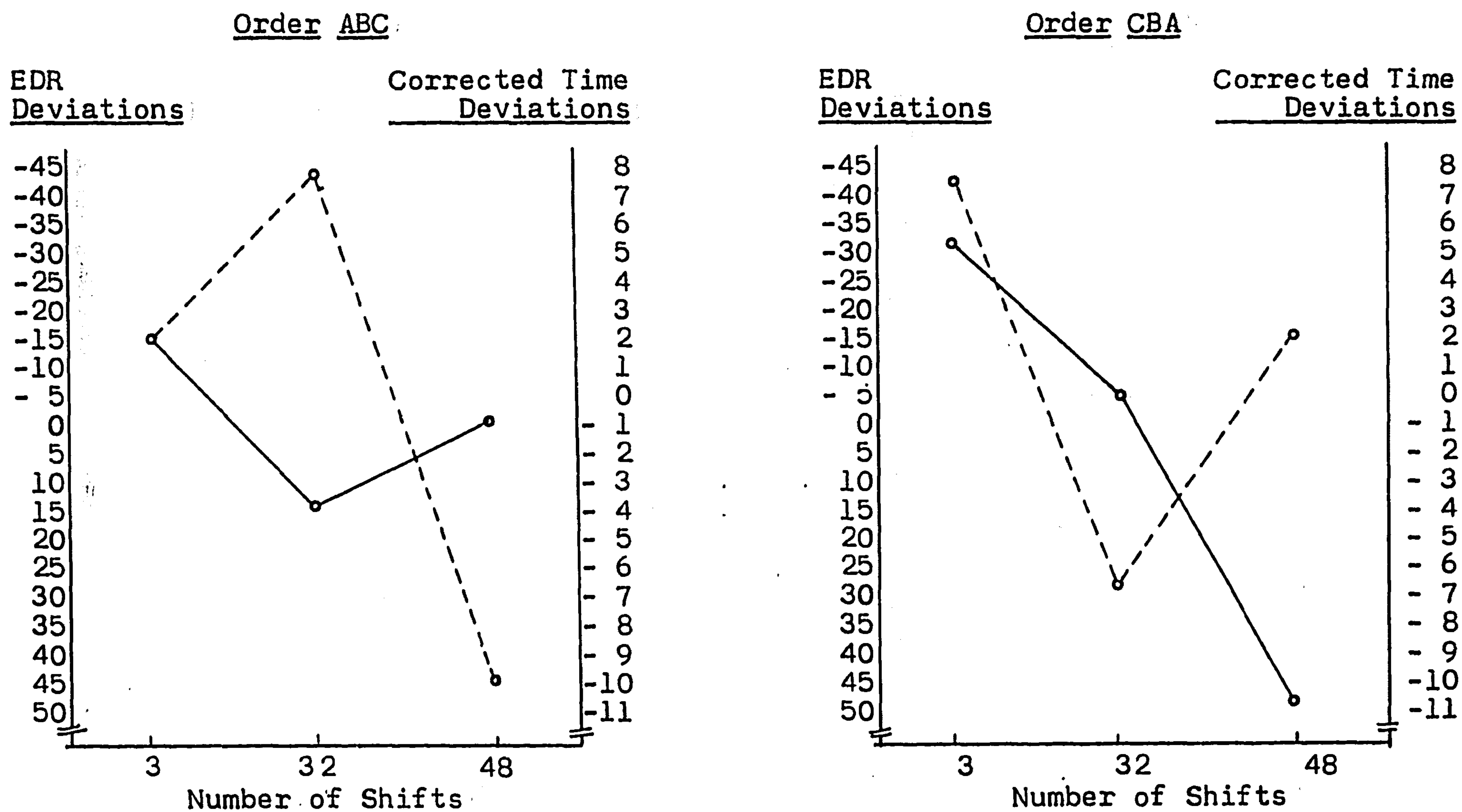

Figure 1. The relationship between the log EDR deviation means and the corrected time deviation means as a function of the number of shifts per page per order.

EDR ———

Time - - -

inversely covariant relationship between the means of these two variables is clearly evident.

Figure 2 presents the regressed EDR means (Linquist, 1953, p. 327) within each order. The EDR deviation scores are arranged as in the previous figure, so that high arousal is toward the top of the graph. For order ABC, the positive slope from 32 shifts to 48 is in the expected direction.

These ABC order results, together with the decreasing estimates of the sigmas of Table 6, 57.9 and 45.8 for sheets B and C opposed to 74.9 for sheet A, suggest that the hypothesis might be confirmed under conditions where the subject has adapted and is responding to the shifts rather than discharging energy aroused in apprehension of the task.

The regressed EDR trend line for order CBA has a negative slope. Between none of the points is there a positive slope. Since this order presents sheets with a decreasing order of shifts, the members of this group apparently have discharged their arousal energy level faster because of adaptation and the available outlet in the easier tasks. The regular decrease of the estimated sigmas for order CBA in Table 6 supports the notion of greater discharge per sheet.

In other words, when the design was selected for counter-balancing learning, practice, and habituation effects, it was assumed that these effects were equal and linear for both orders. Evidently this is not the case.

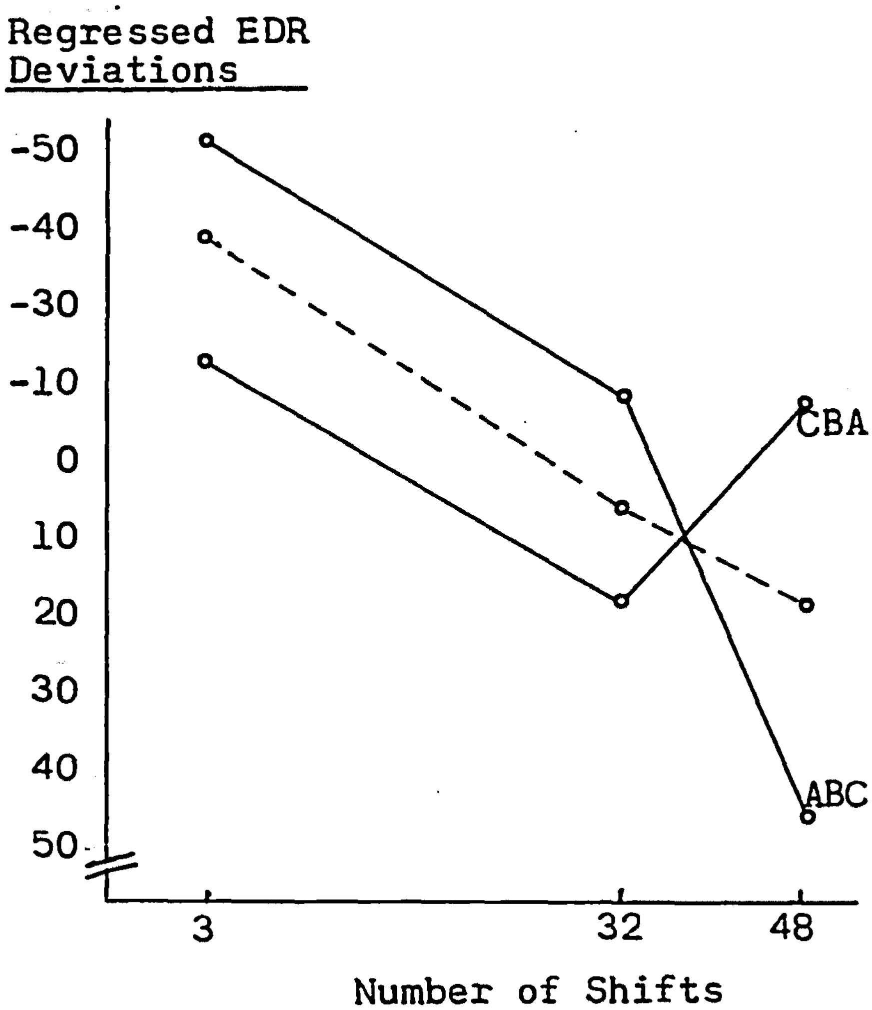

Figure 2. The relationship between the regressed log EDR deviation means and the number of shifts for each order.

- - - Average

——— EDR per order

The rate of building up of muscular residuals is not the same as their discharge rate under conditions such as those in this experiment.

It should be noted from Figure 2 that while the sheets variable was found to be significant, the dashed line between the two order trend lines is similarly in the reverse direction.

In terms of the covariant EDR and corrected time relationship, the complete lack of significance in corrected time scores might call for some explanation. The lack of significance in this variable suggests that the subjects' apprehensions for the situation make it more difficult for them to attend to the required performance. The differences in the trend of the estimated sigmas for time for both orders in Table 7 support this notion. Order <u>ABC</u> sigmas show a regular decrease, order <u>CBA</u> sigmas do not. The final performance of the <u>CBA</u> group on sheet <u>A</u> shows high variability rather than the expected lowest variability indicating that the level of task demands has dropped so far below the subjects' level of readiness to perform that it is difficult for some of them to get down to the required level. This excess energy produces increased variability.

The significant difference in time between the two orders, Table 5, indicates that the subjects of order <u>CBA</u> worked faster for the reasons already cited. Since the sigmas of Table 4 are not significantly different, the increased mean speed would be due to the experimental conditions and not due to differences in selecting subjects for each order.

Staudt and Kubis (1948) reported negative results in a somewhat similar experiment and stated that their subjects were not reacting to the stimuli but rather to the situation in general. The present results and discussion have suggested that the subjects, at least in part, reacted to the specific conditions of this experiment.

The hypothesis that the number of shifts per page will be associated with a significantly greater arousal was demonstrated in part for the ABC order for sheets B and C. A second important finding is the non-reversibility of controls for fatigue, practice, and habituation. Thinking in terms of backlash effects, the building up and the discharging of residuals should lead to more precise experimental designs for research in energetics.

For the immediate future, the next step would appear to be introduction of an habituation session so that apprehension of the task would be decreased. A second step, if necessary, might be to abandon counterbalancing controls and use only the ABC order, controlling residuals through interpolated rest periods. Furthermore, to achieve greater homogeneity of response, subjects with a dread for mathematics might be used and the problems presented automatically at a fixed rate (e. g., on an exposure drum) so that subjects work against a time limit and can not let performance drop off rather than raise their energy levels in the face of increased task demands.

At present there is little if any research in the physiology of set, much less in neuromuscular sets. The beauty of an experiment such as this is in the instrumentation for obtaining the objective shifts.

CHAPTER VII

DISTRACTION AND THE ELECTRODERMAL RESPONSE

During the day many tasks are performed by an individual. Some tasks facilitate the performance of other tasks, some offer resistance or interfere in the performance of other tasks. The internal process by which one of two tasks interferes in the performance of a second task is termed "distraction."

In the earlier experiments on distraction, second tasks sometimes appeared to facilitate performance rather than to hinder it. Morgan (1916), for instance, found a slight retardation in the speed of work at the onset of noise. Adaptation appeared to be rapid with a faster work rate resulting while the noise continued. Subsequent periods of noise and quiet showed no effect on the speed of work.

Laird (1930) calculated a 43% speed-up due to noise for typists who worked in a room to whose walls sound-absorbing material could be added and removed.

Hovey (1928) investigated the effects of auditory, visual, and startle stimuli on the reliability of the Army Alpha test. He found the control group scores higher by 3.7

percentile points. However, Hovey felt that the test administered under the distracting conditions gave a "truer picture" of the subjects in that the spread of scores was reduced.

It was from results such as Hovey's that support was obtained for the concept of energy reserves. Unless the individual is placed under some sort of load, few effects common to a number of subjects will be noted because of the large individual energy reserves (see p. 17). In this case when the distractive load was applied, its effect was a decrease in the variance of the scores.

But this is not the complete picture, for even under distractive loads, the type of response varies. It has been observed that some individuals "go to pieces" under the slightest distraction while others welcome distractions as an aid to mustering high effort for the task at hand. The examples of studying with the radio on and the city dweller's inability to sleep in a more rustic setting due to the lack of traffic rumble are pertinent.

Consideration of the energies involved and the underlying functioning of muscles and neuromuscular sets leads to an integrated explanation in terms of individual differences for the effects so far presented.

Laird (1930) reasoned that the overcoming of distractions must have an associated energy cost. In his experiment noise raised the energy level some 19%, as derived from oxygen and carbon dioxide analysis. Harmon (1933), while finding no change in output under noise conditions, found that oxygen absorption, heart rate, and the breathing rate increased and then adapted. Morgan (1916) noticed the pressure in a response key was heavier under distracting conditions. He also noticed that all the subjects who worked faster under noise increased their speech organ movements and that this affected the inspiration-respiration ratio, which he recorded.

At the physiological level, Davis (1935) showed that the muscle potentials from the forearm were greatest with the onset of noise and least with the cessation of noise. The effect of instructions to inhibit this response was negative, and the response latency was found to be a function of muscular tension. With repetition the muscle potential response tended to adapt.

Poffenberger (1942, pp. 133-135) has presented an excellent summary of this line of experimentation. In addition, Poffenberger (1938, p. 125) suggested that the tensions in Davis' experiment after onset of noise were being mediated by nonfocal musculature.

The experimental proof of this suggestion was forthcoming from Freeman's laboratory (Freeman, 1939). He concluded, from studying simultaneously the tension from the four limbs, that the tension pattern spreads and that the original focus is lost. He went on, however, to state: "These changes apparently are not extensive enough to have much effect on the economy of total energy expenditure" (Freeman, 1939, p. 319).

To see how to provide interfering stimuli which will have enough effect to be noticed, the specific response factors in focal musculature need to be reviewed (see pp. 19-20). Firstly, when displacing stimuli are presented, varying responses have been obtained, depending upon the focal background.

Secondly, facilitation or inhibition effects are multidetermined. These effects depend on "individual differences in habitual energy level, complexity of response required for specific equilibration of a displacing stimulus, the amount, locus, and timing of the induced tension process" (Freeman, 1948, p. 71).

One way to bring these factors into play is to present a series of interfering stimuli so that the subjects would perform under distractive load, and the effects mentioned, plus fatigue, practice, and habituation, would be allowed to accumulate. Perhaps such a procedure would produce changes extensive enough to affect the total energy expenditure.

Does the literature provide guides in the choice of a situation in which interfering stimuli can be presented to produce distractions? Previous experiments have utilized a variety of uncontrolled interfering tasks: phonograph recordings of various noises, horns, gunshots, and even acrobatic acts presented while the subjects were taking a test.

Baker (1937) called attention to the surprise element in interfering stimuli and cautioned that the startle reflex should not be evoked. Ford (1929) found both noise and quiet to operate as distractors. However, Vernon and Warner (1932) found distraction only to intermittant noise when the time of onset and offset was irregular.

According to the Skaggs-Robinson hypothesis, interference is greatest when the interfering task is most similar to the original task. Hence at least two degrees of interference can be obtained by using tasks similar and dissimilar to the one which the subject is required to perform.

It was hoped that the adaptation effect in distraction could be offset by allowing the residuals, the fatigue, habituation, and other factors to accumulate. In addition to these specific and non-specific factors, the intensity or levels of the two interfering stimuli were attenuated in a regular sequence not disclosed to the subjects. This was an attempt to accentuate the distractive effects based on the findings of Ford and of Vernon and Warner.

These controls, it will be noted, affect the EDR. However, the rate of performance is left to the individual subject. Results of studies of performance under distractive conditions indicate at least three types of response:

increased, decreased, and unchanged performance. These performance differences can work against the EDR differences and negate any significant results.

It has been stated that performance and EDR are covariant functions. In order to demonstrate the effects of distraction on the EDR, either performance or the EDR indices could be used as a control variable to correct or regress the other variable for the energy expended to meet the interfering stimulus. In this investigation, the EDR scores were regressed, or corrected, by way of the performance scores to yield an energy score which would show differences due to levels of distraction (see pp. 27-28).

It was expected that there would be significant differences in energy arousal under distraction when the energy arousal indices were corrected for the individual's performance.

Apparatus and Procedures

The subjects for this experiment were thirty volunteer students from the University of Oklahoma psychology classes. Twenty subjects who were exposed to the noise or the typing distractors were members of a class in "effective study" and were "underachievers." An additional control group of ten subjects, who were volunteers from an introductory psychology class, was added later.

Serial addition of the number seven was the original task. A sheet was prepared with a number at the top of each of five columns. The subjects were instructed to add seven to this number and to continue adding seven to each successive sum. There were fifty sums for each column.

The interfering stimuli took two forms differentiated in terms of similarity to the original task: (a) the noise of persons performing the same type of problem was fed into the subjects' earphones at five conditions (levels) of intensity and (b) typewriting noise was fed into the subjects' earphones at five levels of intensity. The five levels of intensity were always presented in the same sequence: zero (no distractor), 1 (low), 2 (medium), 3 (high), and zero again. The second, third, and fourth levels were obtained by turning up the gain control on a tape recorder to predesignated points.

When the analysis of the results for these two groups was underway, it was decided that a more complete answer to the hypothesis could be obtained if a third group of ten subjects who performed the complete sequence of problems with no interference were added. This control permitted a comparison with and without interfering tasks. However, since no "effective study" classes were in session at the time, the ten subjects for this control group were volunteers from a class in introductory psychology. Hence, the differences between this group and those which performed under the two interfering stimuli are compounded by this unavoidable selection factor.

Subjects were welcomed at the laboratory casually and put at ease concerning possible shocks in the EDR apparatus. This apparatus was similar to the one described in the previous experiments. The members of the control group which was added later had their EDR's recorded on an Esterline-Angus ink writing galvanometer which was fed from the vacuum tube voltmeter amplifier. Otherwise the circuit was similar to those used in the other experiments.

Instructions to all groups were that this was an experiment in distraction and that they were to expect noise in the earphones.

The resistance scores were converted to log resistance readings, and the median for each noise level was taken as the representative score. These median scores for each subject were subtracted from each subject's mean to obtain a deviation EDR score from the work level. This linear transformation does not correct the major disadvantage of using a log resistance measure that a high score indicates a low energy level and vice-versa (see pp. 37-38).

To obtain information on the relationship of EDR and performance under distraction, the time taken to complete each set of fifty scores was recorded. Errors were penalized at 1/50th of the total time for each error. This gave rise to corrected time scores, for which deviations from the subject's time score mean were taken to produce corrected time scores to parallel the EDR deviation scores.

Dealing with the EDR deviation scores and corrected time deviation scores has the effect of making each subject's total score for the conditions in which he served zero. In other words, deviation scores eliminate individual differences and preclude an analysis of differences between the three distractor groups.

In order to overcome this difficulty, each subject's total score previous to transforming the data into deviation scores was subjected to a separate analysis of variance. These scores will be referred to as "Individual Difference Means" in all tables.

Results and Discussion

The basic data for the covariant log EDR and corrected time variables are presented in Tables 25 and 26 of the Appendix.

Tables 9-12 present the individual difference data analyses for both variables. Homogeneity of variance was present for the individual difference means of Table 9 and also for the individual difference means of Table 11 (Walker & Lev, 1953, pp. 462-463).

Analyses of variance for these data, Tables 10 and 12, indicate that the three groups differ significantly in their corrected time score means. The control group mean of

Table 9

Means and Estimated Standard Deviations for the EDR Individual Difference Means for Distraction

	Voice Distraction	Typing Distraction	Control Group
Mean	401.5*	425.0	417.6
Est. S. D.	32.7	30.1	42.7

*Log EDR means times 100.

Table 10

Analysis of Variance for the EDR Individual Difference Means for Distraction

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F	P
Total	37,086.20*	29			
Groups	2,887.30	2	1443.70	1.14	>.20
Error	34,198.90	27			

*Log EDR scores times 100.

Table 11

Means and Estimated Standard Deviations for the Corrected Time Individual Difference Means for Distraction

	Voice Distraction	Typing Distraction	Control Group
Mean	202.1*	173.7	249.4
Est. S. D.	65.4	67.5	66.0

*Corrected time scores in seconds.

Table 12

Analysis of Variance for the Corrected Time Individual Difference Means for Distraction

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F	P
Total	150,361.20*	29			
Groups	29,247.80	2	14,623.9	3.26	$<.05$
Error	121,113.40	27	4,485.7		

*Corrected time scores in seconds.

249.4 seconds significantly exceeds the typing distraction group mean of 173.4 seconds. This difference between the control and the distraction groups may contain a selection factor in that the control group's subjects were from summer session introductory psychology classes (see p. 69). This could mean then that summer session students are more cautious workers and hence paced themselves more slowly than regular session students on the addition task.

Tables 13 and 14 present the means and estimated standard deviations for both variables. For the EDR deviation scores, Cochrans' test of homogeneity of variance (Eisenhart, Hastay, & Wallis, 1957, pp. 390-391) indicated a probability between the .01 and .05 levels. The same test of homogeneity exceeded the .01 level for the corrected time score variances (Eisenhart, Hastay, & Wallis, 1957, pp. 390-391).

To check further on the assumptions underlying the analysis of covariance technique, within cells correlation plots were drawn. The small N within cells made the judgment of homogeneity of regression tenuous. Nevertheless, linearity and homogeneity appeared to be lacking. The means of Tables 13 and 14, however, indicate some positive correlation upon which the covariance analysis might capitalize.

Table 15 presents the analysis of covariance (Linquist, 1953, ch. 14) and the analyses of variance results. The analysis of covariance shows that the levels variable,

Table 13

Means and Estimated Standard Deviations for the EDR Deviation Scores for Distraction

Groups		Noise Levels 0	1	2	3	0
Voice Distraction	Mean	8.3*	3.6	-1.0	-5.4	-5.5
	Est. S.D.	15.8	5.8	8.2	6.7	9.4
Typing Distraction	Mean	7.3	3.0	1.1	-5.2	-6.2
	Est. S.D.	4.5	3.5	4.8	5.5	5.4
Control	Mean	2.7	0.6	3.5	0.8	-7.4
	Est. S.D.	10.5	7.1	6.6	4.0	9.5
TOTAL MEANS		6.1	2.6	1.2	-3.3	-6.4

*Log EDR deviation scores.

Table 14

Means and Estimated Standard Deviations for the Corrected Time Deviation Scores for Distraction

Group		Noise Levels 0	1	2	3	0
Voice Distraction	Mean	12.2*	15.4	7.1	-1.4	-33.3
	Est. S.D.	29.3	27.0	27.3	30.5	31.5
Typing Distraction	Mean	25.6	4.6	-3.0	-8.7	-18.5
	Est. S.D.	30.2	14.4	17.8	18.4	16.5
Control	Mean	43.5	-2.9	-19.7	5.4	-26.3
	Est. S.D.	116.7	50.9	54.8	54.7	60.8
TOTAL MEANS		27.1	5.7	- 5.2	- 1.6	-26.0

*Corrected time score deviations.

Table 15

Analyses of Variance and Covariance for the Log EDR Deviation Scores and the Corrected Time Deviation Scores for Distraction

Source	Degrees of Freedom	EDR Sum of Squares	Variance Estimate	F	P	Time Sum of Squares	Variance Estimate	F	P
Total	149	12,610.00**				346,418.00**			
Between Subjects	29	0.00				0.00			
Group	2	0.00				0.00			
Error	27	0.00				0.00			
Within Subjects	120	12,610.00				346,418.00			
Levels	4	2,863.00	715.95	8.44	$<.001$	44,223.80	11,055.94	4.12	$<.005$
Levels x Groups	8	588.00	73.50	1.51	$<.20$	12,379.40	1,547.43	.58	$>.20$
Error	108	9,158.20	48.80			289,814.80	2,683.47		

Source	Cross Products Sum of Squares	Adjusted EDR Sum of Squares	Adjusted Degrees of Freedom	Adjusted Variance Estimates	F	P
Within Subjects	3,794.00					
Levels	5,955.50	2,976.93	4	744.23	8.80	$<.001$
Levels x Groups	3,568.30	685.87	8	85.73	1.01	$>.20$
Error	-5,729.80	9,044.92	107	84.53		

*Log EDR deviation scores plus 50.

**Corrected time deviation scores plus 200.

or the differences in intensity 0, 1, 2, 3, 0, is the only significant variable. This same variable is the only one significant in each of the analyses of variance.

Figure 3 indicates the trends for both variables in each of the three groups. Since the covariance analysis lends little to the analyses of variance results, the regressed EDR trend line would be close to that of the unadjusted EDR trend line of Figure 3. The variation in trends between the two distraction groups and the control group is not significant.

The trends indicated by the EDR means in Figure 3 are what were expected. Clearly, greater arousal of energy is indicated by the positive trends. However, one can reasonably ask whether these results are not due to the accumulation of residuals, warm-up effects, and fatigue.

Certainly some portion of the trends is due to these factors. Some evidence for this is forthcoming in the lack of a difference in trend between the two distraction groups and the control group. However, it should be remembered that the control group's instructions were also to expect noise in the earphones. It can therefore be equally well argued that the control group was distracted in attempting to overcome an expectancy set for noise.

The control group had no real distraction, only an expectancy, which was present in both of the other groups.

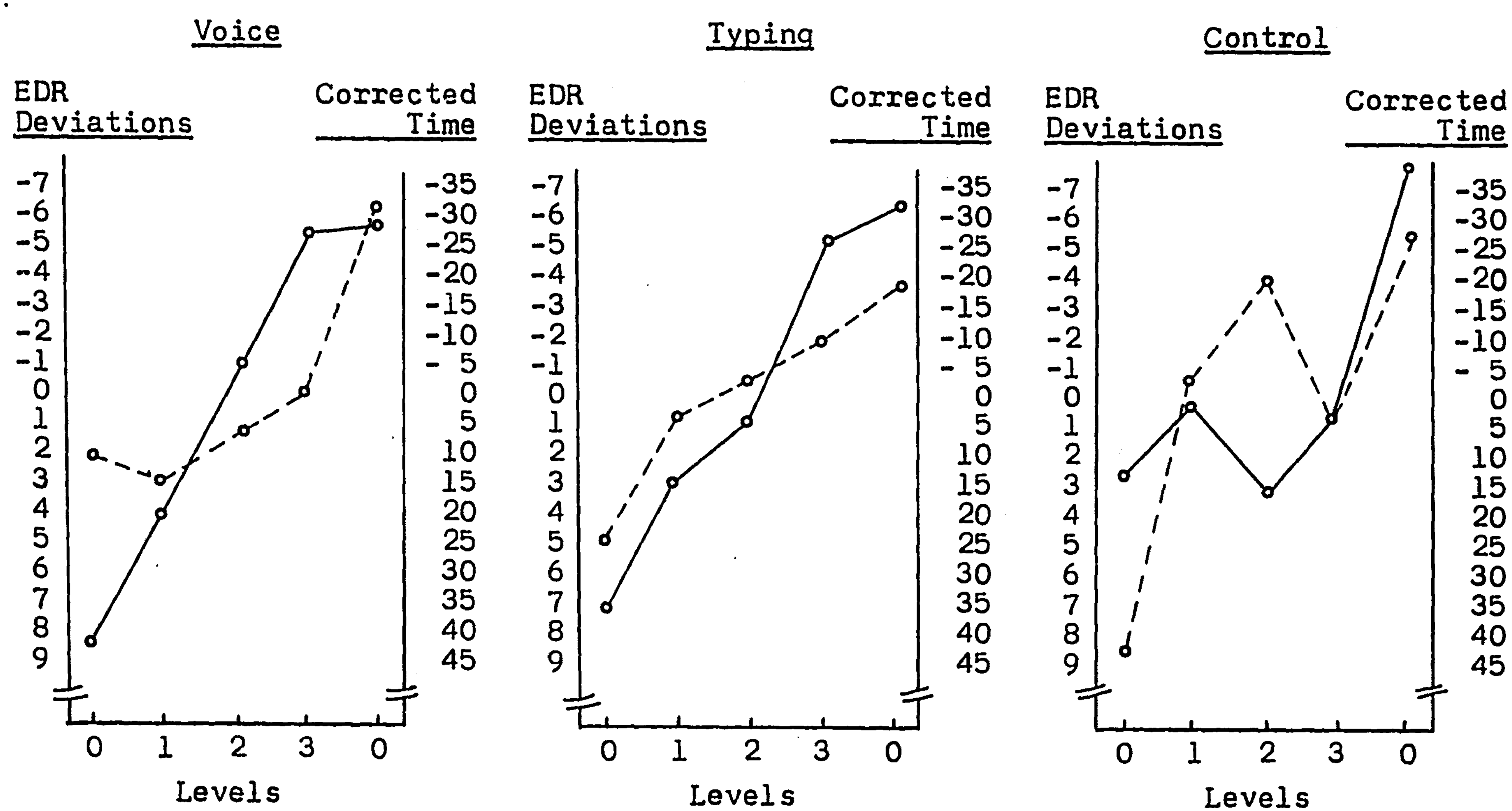

Figure 3. The relationship between the log EDR means and the corrected time score means for the distraction conditions.

EDR ———

Time - - -

It may be that, for both distraction groups, the fact that the EDR curve ceases its steep climb from the 3 to the final O is an indication of the cessation of distraction increments. In a rough sort of way the control group provides the picture of accumulated residuals, accelerated curve. More often than not, residuals accumulate in such a progressive fashion, giving rise to the notion that, although residuals from the task may accumulate in a uniform linear fashion, the job of carrying these residuals constitutes an additional increasing load so that the total effect should be some sort of an increasing geometric or exponential function (see p. 20). This does not show in the two distraction groups, presumably because the middle portions of the curve are boosted up by additional task loading.

It is felt that these EDR data indicate that under distraction and where residuals are allowed to accumulate, energy arousal increases to meet the demands of the task situation.

In Figure 3, the mean time trends are indicated by the dashed lines. These trends are positive, indicating shorter times as the performance residuals, warm-up, fatigue, and adaptation effects mount. The analysis of variance of corrected time scores (Table 15) yields the same pattern of significance as for the EDR variable. In the face of this similarity of trends and significance patterns, why is the relationship between performance and EDR so weak that the analysis of covariance adds little to the pattern of significance of both variables?

It is suggested that the lack of the within-groups correlation, which would improve the covariance results (McNemar, 1949, p. 329) might be due to those personality factors which deal with how situations of this type are met. In the absence of clearer specifications of these characteristics (see p. 26) selection on certain modes of response variables will have to be utilized.

When this experiment is repeated, and it should be, subjects for the distraction and control groups should, of course, come from the same population, if possible. The data of this experiment raise a question concerning expectancy residuals interacting with task load residuals.

A somewhat different, simplified situation is suggested. Subjects should be classified as to their response under interfering conditions. After a resting level has been achieved, the subjects should work under no distractor, then under an intermittent noise distractor. These data should then be analyzed for the relationship between energy arousal and performance responses in these selected groups. Such an analysis might provide hints as to those personality factors which need to be controlled in energetics experiments such as how individuals carry task loads in addition to distraction loads.

CHAPTER VIII

EGO-INVOLVEMENT AND THE ELECTRODERMAL RESPONSE

Thurstone and Chave define an attitude as "the sum total of a man's inclinations and feelings, prejudice or bias, preconceived notions, ideas, fears, threats, and convictions about any given topic" (Underwood, 1949, p. 89). In short, attitudes are complex sets or behavior tendencies.

In recent years, the term "ego attitudes" has come into general use to designate the behavior tendencies of an individual towards himself (Sherif, 1948, chs. 11, 12). Since the Freudian ego and super-ego are both learned products, the more social minded psychologists have combined these two Freudian concepts into the one term "ego" or self.

All attitudes are learned and all are, of course, self-referant in that they represent positively or negatively cathected feelings. However, ego attitudes are not simply the sum total of the cathected feelings. They are an organized group of attitudes dealing with the self, its capabilities, its projection into the future, its enhancement, and its maintenance in the face of frustration and threat. It is as if a complex object, a picture, made up of the roles a subject has played, and the collection of self-pictures as reflected by other persons, develops and forms a "frame of reference" (Sargent, 1950, p. 212), on the basis of which the subject acts.

Many studies of personality take on meaning and can be explained in an ego-theory frame of reference (Underwood, 1949, pp. 192-198). Level of aspiration studies (Lewin, Dembo, Festinger, & Sears, 1944) reflect an individual's optimism or pessimism concerning the future as based on his past experience. Ego-involvement studies (Underwood, 1949, p. 192) are usually studies in which there is a threat to an individual's prestige or self-esteem.

Coleman (1956, pp. 60-105), the author of a very widely used text in abnormal psychology, views the Freudian defense mechanisms as learned response habits to protect and maintain the ego. Threats, not allayed by defense mechanisms, instigate feelings of anxiety, which, being painful, become motivators. Mowrer (1940), Miller (1948), and Brown and Jacobs (1949), have dealt with anxiety reduction as a motivator for behavior when the ego defenses are not adequate. Thus anxiety is a signal that the ego defenses have been broken through.

This description of the maintenance of the ego through defense mechanism and a secondary defense of anxiety reduction behavior is another instance of homeostatic regulatory principles. This is, as Freeman states, the highest adjustment level for the organism:

> A higher and more complicated level is found in the generalized emergency reactions of the total organism, integrated with the autonomic nervous system. The highest level involves cerebrally controlled total behavior, including response that is specifically adaptive to external stimulation and the so called "ego defenses" that guard the inviolacy of the personality from psychological insult (Freeman, 1948, p. 98).

What is implicit in this homeostatic view is that diffuse neuromuscular circuits represent the ego and that threats to the ego interfere at vulnerable points with the diffuse pattern. Some support for this view comes from the work of Jacobson who taught subjects to rid themselves of stress by exercising particular muscle groups (see pp. 14-15).

Further support for the neuromuscular ego concept comes from the work of two analysts, Ferenczi (1953, pp. 198-233) and Reich (1949, ch. 15). Ferenczi has noted that a great flow of blocked associations occur when certain patients are allowed to exercise muscles in the body member where stress is felt during resistance periods in the therapeutic session. Reich has gone farther by prescribing a set of exercises which involve muscles and nervous centers in man which are highly important centers for animals in the evolutionary phylogenetic sequence. Hence, both Ferenczi and Reich imply that the ego system is at least partly a neuromuscular system.

With specific reference to the present investigation, when subjects are asked to talk about statements culled from a personality inventory, some of these items will be perceived as an ego-threat. The EDR should record the energy arousal to overcome the threat to the ego system.

Stagner (1948, p. 202) states that an attitude is characterized always by (a) an object, (b) a direction, and (c) intensity. Thus far, the object of ego attitudes has been discussed. Intensity and direction need also to be discussed.

Those attitudes which are intense and which are responses to ego-threats are ego-involving attitudes. It is suggested that energy arousal as measured by the EDR will reflect levels of ego-involvement. Although we may assume, as a first approximation, that this relationship is linear or perhaps exponential, the relationship obtained in any particular study is also a function of the attitude scale used. It should be noted that an attitude may be either positive or negative and still be strong. Thus a scale which runs from neutral to strong positive (or strong negative) will show the relationship to be linear (or perhaps exponential). But a scale which runs from strong negative through neutral to strong positive will show a _U_-shaped function. The scale chosen to measure ego-involvement in this investigation had a neutral point at its center, thus it should produce a U-shaped function.

More precisely, subjects were presented with statements from a personality self-report inventory and a Rogerian-type (Rogers, 1942) interview was conducted about each item. The subject and two clinical judges rated the subject's response on a five point involvement scale. The relationship between these ego-involvement ratings and EDR should be U-shaped.

There have been at least two broad types of ego-involving experiments: (a) those such as Alper's (1946) in which instructions are used to set the degree of involvement, and (b) those similar to Levine and Murphy's (1943) in which the material learned and remembered was shown to be a function of long held attitudes. It will be seen that the present investigation is most similar to type (b) but is a more life-like situation than the usual laboratory ego-involvement experiment in that the attitudes are more central to the individual's functioning.

Within this investigation, a high relationship between levels of involvement and EDR should be evident. Allport (1943) has pointed out that the concern with ego-involvement in experiments is useful in that the usual means of inducing motivation are brought into question. Does the subject actually "take" the verbal instructions presented to motivate him? Do "neutral" instructions or no instruction at all control motivational factors adequately? With the

EDR indicator, and scales built as described above, an answer to Allport's questions would be available.

Method

The subjects for this experiment, drawn from an elementary psychology course, were twenty-five students, six of whom were women, who had indicated on an earlier questionnaire that they were "prone to worry" and would volunteer for a psychological experiment. They were between eighteen and twenty-five years of age.

These subjects were greeted casually at the laboratory, and the functioning of the EDR apparatus was explained to them to alleviate fears of electrical shock. They were then asked to relax for at least 15 minutes while a basal EDR level was established.

When this stage of the experiment was completed, a Rogerian-type interview (Rogers, 1942) was carried out in regard to twelve items chosen from the Bell Adjustment Inventory (Bell, 1934). The subject also checked the degree to which the statement was "true" for him on a scale whose five divisions were as follows: Yes, more yes than no, can't say, more no than yes, and no.

Bendig (1953) has shown that scales of five, seven, and nine points have about equal reliability which increase as a function of the number of anchors. Five scale divisions, fully anchored, were chosen so as not to place an undue burden on the subject. However, the subjects' resulting classification is dependent, as can be seen, on his understanding of ego-involvement. Singular, varied efforts were made to attempt to communicate this notion to each subject.

At the discretion of the experimenters, when the subject seemed highly involved, one of ten buffer items chosen from those designated as "neutral" on the Taylor Manifest Anxiety Scale (Taylor, 1953) was administered. This procedure was utilized in an attempt to control the spread of involvement in the twelve test items.

For each item administered, the subjects' palmar resistance was read from the vacuum tube voltmeter at the rate of four readings per minute. The circuit was similar to that used in the other experiments.

When the subject made his classification, two experimenters also classified his response on the five point scale similar to that used by the subject. The application of the five point scale and the criteria for each point were discussed previously by the two judges. These criteria are presented in the Appendix.

The log basal resistance was subtracted from the log median resistance value for each item to obtain resistance levels. The resistance level scores for each subject were averaged for each of the response classification categories. It is because of this averaging within each rating scale category that the total number of responses for Tables 27 and 28 in the Appendix, the subjects' and the experimenters' classifications, do not coincide.

Both sets of data were subjected to an analysis of variance and the significant *F* ratio transformed into an eta-squared which is a measure of relationship (Peters & Van Voorhis, 1940, pp. 353-357). As previously explained, high EDR means low arousal and vice-versa.

Results and Discussion

Tables 16 and 17 summarize the data for the subjects' classification. There are significant individual differences but classification differences are not significant.

A moment's reflection will show that this failure on the part of the subjects to accurately gauge their degrees of involvement or threat should have been anticipated by the experimenter. Subjects who undergo threat or anxiety experience diffuse pain; they seldom know what is wrong. There are, of course, degrees of insight in subjects, but for naive subjects this state of affairs is itself symptomatic of the response to an ego-threat.

The data for the two experimenters, one a beginning clinical student--the other an advanced clinical student, differ from that of the subjects. Tables 18 and 19 present these data and indicate, in addition to the significant subject variance, significant differences between the category means, *F* equals 3.33, with a probability value of less than

Table 16

Means and Estimated Standard Deviations for the Log EDR Scores for the Subjects' Classification of Ego-Involvement

	No	No>Yes	Can't Say	Yes>No	Yes
N	24	20	11	16	19
Means	- 2.21*	- 2.13	- 2.37	- 3.04	- 2.17
Est. S. D.	28.7	32.5	46.4	76.0	32.2

*Log EDR difference scores.

Table 17

Analysis of Variance for the Log EDR Scores for the Subjects' Classification of Ego-Involvement

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	*F*	*P*
Total	2,929,963.16*	89			
Subjects	1,820,109.98	24	75,837.92	4.56	$<.01$
Categories	95,948.47	4	23,987.12	1.44	$<.20$
Residual	1,013,904.71	61	16,621.39		

*Log EDR scores times minus 100.

Table 18

Means and Estimated Standard Deviations for the Log EDR Scores for the Experimenters' Classification of Ego-Involvement

	No	No>Yes	Can't Say	Yes>No	Yes
N	13	23	14	25	22
Mean	- 3.09*	- 1.93	- 1.91	- 2.19	- 2.52
Est. S. D.	51.9	27.2	47.2	26.2	39.1

*Log EDR difference scores.

Table 19

Analysis of Variance for the Log EDR Scores for the Experimenters' Classification of Ego-Involvement

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	F	P
Total	2,462,910.03*	96			
Subjects	1,570,173.42	24	65,423.89	5.96	$<.01$
Categories	146,145.77	4	36,536.44	3.33	$<.05$
Residual	746,590.81	68	10,979.28		

*Log EDR scores times minus 100.

.05.

Figure 4 presents this significant relationship. Eta-squared, the measure of relationship is .115 with a probability of significance between the .05 and the .01 levels. Eta, interpretable as a coefficient of correlation, equals .34 (Peters & Van Voorhis, 1940, pp. 353-357).

Bartlett's test (Edwards, 1948, pp. 197-198) for homogeneity of variance was significant beyond the .001 level for both the subjects' and the experimenters' classification of the data. It is felt however, that this would not change the interpretation of results (see pp. 36-37).

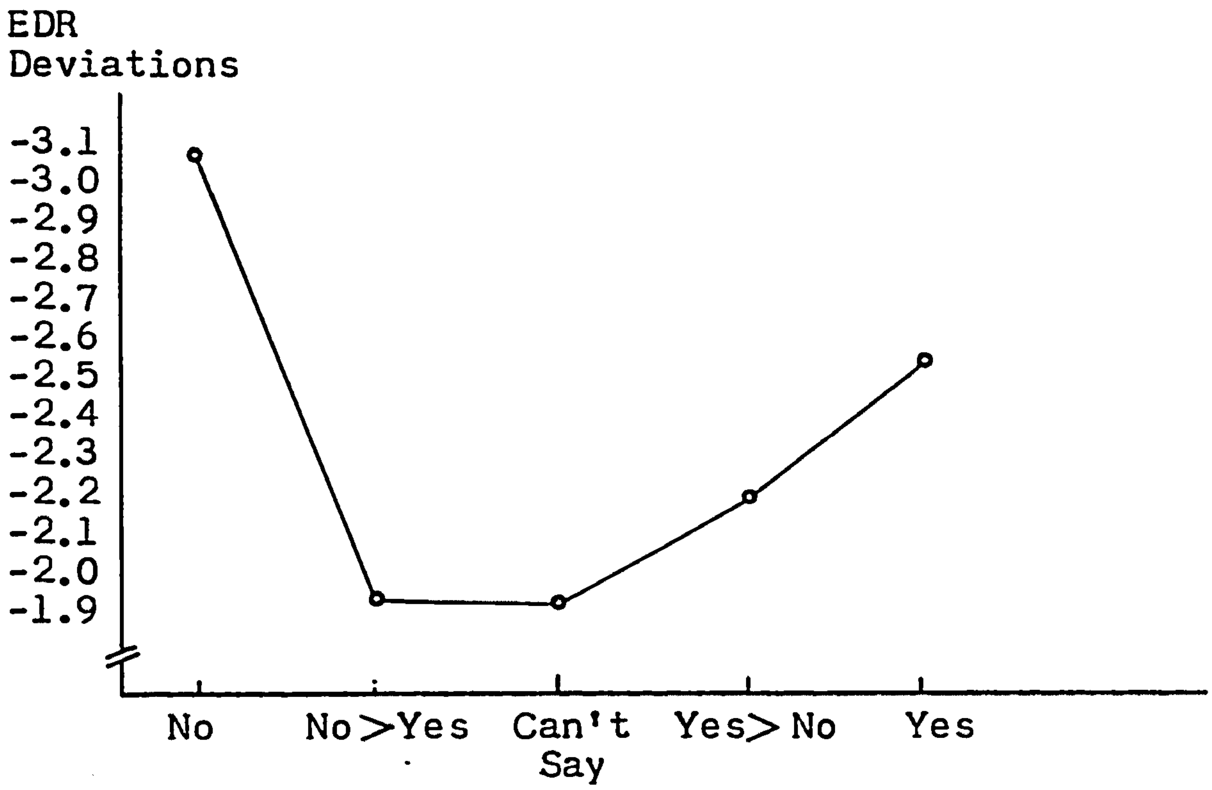

Figure 4. The relationship between the log EDR means of the experimenters' classification of the degree of ego-involvement.

It should be noticed from Figure 4, that the curve is indeed _U_-shaped. Evidently the _yes_ point is not as strongly felt as the _no_ point on the scale. Lowest arousal appears between the _can't say_ point and the _no more than yes_ point.

These results indicate that degrees of ego-involvement and energy arousal are significantly related. For this experiment subjects who underwent threat could not gauge their own degrees of ego-involvement. This inability is itself seen as a symptom of anxiety.

These results should open the way for other research. For instance, would improvement in a subject's ability to gauge his ego-involvements coincide with progress in therapy? Could ego-involvement judgments leading to a reliability index be used to gauge the degree of training of a clinical aspirant?

Unfortunately, in this experiment, the judges were required to agree on all responses and to settle all differences between themselves. No reliability of agreement data were kept. Nor, for that matter, were any checks made between the response to buffer and nonbuffer items. This last check would have provided auxiliary data to help decide how well the judges functioned. Perhaps in subsequent experiments each threat item should be followed by a buffer item.

Lastly, in providing an objectively measurable physical continuum, EDR, studies such as this may have implications for scaling values and attitudes which at present can not be referred to physical scales. In this connection, Thurstone (1948, p. 130; 1954, p. 50) has stressed the difference between the Fechner and Weber laws. The former expresses a relationship between a physical and a subjective continuum; the latter is usually interpreted as dealing only with a subjective continuum.

CHAPTER IX

PERCEPTION AND THE ELECTRODERMAL RESPONSE

The previous chapter dealt with a long term neuromuscular set which was the ego. However, a moment's reflection will show that there are also short term temporary sets. For instance, if one were attending to street names and expected the next street to be Elm, he would have created an "expectancy set." Whether or not this set is dissipated would depend on fulfillment or the lack of fulfillment of the expectancy.

The duration of these sets depends on the course of neuromuscular homeostasis (see pp. 19-20). When a stimulus displaces the organism, the events that follow depend on the focal background, the number and variety of motor outlets, and specificity of the response (Freeman, 1948, p. 122). If these do not discharge the aroused energy, reactivation occurs and the discharge sequence is once more instituted.

Underlying the concept of reactivation is the hypothesis of "backlash action" or feedback. Every motor response, according to Freeman, reports centrally by backlash action. The consequences of this report are summarized:

> It helps explain why some overt responses bring relaxation and quietude, whereas others only increase internal excitement and raise the general energy level. The most adaptive response is not necessarily the one which brings most rapid and complete recovery from stimulus-induced excitement. Such recovery is accomplished, by hypothesis, when the central backlash effects of the response in question are specific rather than generalized; that is, the motor processes report back neurochemically to the specific centers generating the action instead of diffusing the re-excitatory effect. The relation of such specific effects to "trace theories of fixation" is a matter of vital concern in the psychology of learning. Contrawise, nonspecific backlash effects may be invoked to explain why conflicting, blocked, and inappropriate reaction to frustration stimuli raise rather than lower the general level of internal excitement. It appears that (other things equal) the more the motor response to stimulation is specifically concentrated in a limited number of reaction arcs, the less is its over-all re-excitatory effect. Furthermore, the more specifically the major part response is connected with "doing something about" the stimulus the less the total backlash excitation. Presumptively, the ratio of specific to non-specific backlash from overt response has even greater bearing on the subsequent pattern of energy distribution than it has on total quantitative changes in general energy level (Freeman, 1948, pp. 106-107).

Now, the discharge of arousal energy must be in "moderation." Underdischarge, it will be seen, leaves residuals. Overdischarge, on the other hand, also leaves an imbalance and re-excites the system by backlash action (Freeman, 1948, p. 127).

Thus far, the homeostatic principles discussed have been confined to the processes underlying two of the major portions of the homeostatic cycle: energy mobilization and discharge. The third phase is recovery, the phase in which discharge exceeds arousal and the organism either returns to or establishes a new level from which subsequent displacement occurs (see pp. 18-19).

Recovery, defined in this way, is dependent in a very large sense on discharge factors and in particular on feedback or backlash effects. Feedback, it will be recalled, was one of the principles of system theory (see p. 3).

Yet, with possibly few exceptions, feedback has not been widely used to explain psychological behavior at a physiological level. The application of feedback has been made on a largely analogous basis to social situations.

For instance, in the experimental work on a theory of decision (Edwards, 1954; 1956), the amount of money which an individual is willing to wager has been studied in relation to the information the subject possesses of the outcomes of his previous wagers. In one sense these are studies in learning; in another sense they are studies in the feedback of information and the degree of utilization of that information to reach a decision. Recently there have been some attempts to apply information theory (see p. 2) to psychology (Attneave, 1955a; 1955b; 1956; Cherry, 1952; Grant, 1954; Miller, 1953).

Katona (1953) discusses the aid which psychology could give in understanding economic behavior. Certainly a theory of decision would make possible a much more accurate and scientific theory of economics.

The effects of speaker-audience feedback on changes of attitude have been investigated by Thistlethwaite and his co-workers (Thistlethwaite & Kamenetzky, 1955; Thistlethwaite, deHaan, & Kamenetzky, 1955). Evidently, to produce changes of attitude, the speaker should elaborate his refutation of the opposition argument. It also helps if he concludes with an organized restatement of the issues, his and the counterpositions.

Communication nets would appear to be the most flexible method of varying communication channels and information in a multiple feedback system. Lines of communication, that is, who passes the information to whom, can be specified. For instance, in the wheel net all individuals must obtain and receive their information from the individual at the hub. Shaw and others (Shaw, 1954a; 1954b; 1954c; Gilchrist, Shaw, & Walker, 1954; Leavitt, 1951) have studied different types of nets, the amounts of information, and leadership in relation to "centrality" in the net.

These lines of investigation, while interesting in themselves, fail to come to grips with the underlying physiological mechanisms of behavior. The exception, other than the Freeman-Dashiell neuromuscular set theory, is Lorente deNó's (Morgan & Stellar, 1950, p. 75) demonstration of reverberating neural circuit pathways.

While much lip-service has been paid to the reverberating neural circuits by the physiological psychologists, little seems to have come of it. In the meantime, the neuromuscular view, being somewhat more complicated and less pure, has been largely ignored.

The purpose of this investigation is to demonstrate the effect of feedback. In the quotation previously cited from Freeman (see pp. 19-21), it will be recalled that residuals have much to do with the Ziegarnik effect. That is, tasks which subjects are blocked from completing are recalled more often than those tasks which have been completed.

Following the Ziegarnik effect and the attempted explanation in neuromuscular terms, subjects were presented completed and non-completed perceptual recognition tasks. It was hypothesized that there would be a greater change in EDR from the working to the resting level for the completed task than for the noncompleted task. Or restated, it was expected that fulfilled expectancy sets would produce a significantly greater change in the EDR than unfulfilled perceptual expectency sets.

Method

The subjects for this experiment were twenty volunteer students from elementary psychology courses. Eleven of these twenty were men, nine were women. All subjects were between eighteen and twenty-four years of age.

These subjects were greeted casually at the laboratory, and the functioning of the EDR apparatus explained to them as a "sort of lie-detector." Fear of shock was allayed and the subjects were requested to relax so that a basal EDR level might be obtained.

During this basal period, as well as throughout this experiment, the subjects' resistance levels were recorded automatically with an ink-writing galvanometer. Electrodes were two plastic cups of a design in use at the laboratory and were both worn on the palm of one hand (see p. 34). The EDR circuit was a current measuring type.

Luchins' two-picture series were used as the stimuli (Luchins, 1945). Each subject viewed the two sets of slides, both sets starting with a drawing of a man's face. In one set of slides, the "complete set," the man's face becomes distorted and then the jumble of lines and curves resolves into a picture of a milk bottle. In the second or "noncomplete set" the man's face simply becomes successively distorted into a jumble of lines and curves.

Subjects were assigned randomly to one of the two presentation orders. Not all of the pictures in either series were shown. Rather, a selection of eleven pictures from each series was made. The pictures from the complete set series were numbers: 1, 3, 5, 7, 9, 11, 13, 15, 19, 21, and 22. Pictures 1 through 11 of the noncomplete series were shown. It can not be claimed that the psychological differences between pictures were in any way equal.

At the end of an approximately ten minute initial period the subjects were told that they would see a series of pictures projected on a screen ahead of them. They were to tell the experimenter what they saw in each of the pictures.

Subjects were scheduled for 50 minute periods so that the readings would not include a response to the school bell system. Each subject rested for ten minutes, was presented the first perceptual task for the next ten minutes, rested for ten minutes, was presented with his second perceptual task, and then again rested for ten minutes.

Short notes of the subject's reports for each picture were kept by the experimenter. Because of varying amount of response, the timing for the two tasks varied somewhat. Therefore the times for each of the five phases of the experiment varied somewhat from subject to subject.

Median log EDR readings were obtained for each five minute period: three for each of the perceptual tasks, and two each for the intermediate and final rest periods. The initial ten minute rest period was not judged adequate for establishing a reference level and an average work level for ten readings for each subject was used instead.

The hypothesis states that the change from the task level to the resting level will be significantly greater for the completed set than for the noncomplete set pictures. For each subject, for each set of pictures, the three task level scores were averaged, the two resting level scores for the immediately subsequent rest period were similarly averaged, and the difference was computed. There is no reason why these differences should sum to zero. Hence a single analysis of variance, including individual differences, is feasible.

However, this particular analysis of variance design has been identified as a two by two latin-square crossover design by Stanley (1954a; 1954b). In such a design the interaction term becomes the sequence variable, first versus second presentation, and the final error term is only approximate. Stanley's analysis was followed.

Results and Discussion

Original log EDR scores are presented in Table 29 in the Appendix. Means and standard deviations for the two orders are presented in Table 20. Hartley's test for homogeneity of variance (Walker & Lev, 1953, pp. 462-463) showed homogeneous variances.

The results of the analysis of variance are presented in Table 21. None of the variables is significant. A slight tendency for smaller difference means for the completed sets is indicated in Table 22. Evidently these differences, when corrected for sequence and group differences, do not reach significance.

In view of the results of the previous experiments, it is felt that the lack of significant results in this experiment is due to the nature of the perceptual tasks.

Table 20

Means and Estimated Standard Deviations for the EDR Level Differences for the Perception Experiment

Order		Noncompleted	Completed	Individual Differences
Noncompleted	Mean	2.0*	1.7	3.7
Completed	Est. S.D.	6.27	7.41	48.16
Completed	Mean	0.1	-1.3	-1.2
Noncompleted	Est. S.D.	8.06	9.66	44.60

*Log EDR difference scores.

Table 21

Analysis of Variance for the EDR Level Differences for the Perception Experiment

Source	Sum of Squares	Degrees of Freedom	Variance Estimate	*F*	*P*
Total	2,343.44*	39			
Between Subjects	1,851.94	19			
Order	60.09	1	60.09	1.37	>.20
Error	791.85	18	43.85		
Within Subjects	491.50	20			
Treatment	7.29	1	7.29	.27	>.20
Sequence	3.09	1	3.09	.12	>.20
Error	481.13	18	26.73		

*Log EDR difference scores plus 25.

For college students, while this type of material is interesting, it fails to provide a meaningful, involving task. Without such a task, the energy changes within the individual are minor.

CHAPTER X

DISCUSSION

System theory was presented as a framework which might possibly lead to unifying principles both within psychology and between psychology and the physical and biological sciences. The key notion in such a theory is that it deals with energy exchanges between systems or subsystems.

G. L. Freeman has attempted to describe human functioning in an open system theory based on the broadened notion of homeostasis. Response system functioning is explained by Freeman in terms of neuromuscular homeostasis.

For Freeman, the symbolic process which underlies learning, motivation, reasoning, and the ego, is carried by neuromuscular sets. Much of psychological functioning, therefore, deals with the arousal and directing of energy to construct and maintain these neuromuscular sets.

If Freeman is correct, psychological activity should be reflected as modulations of the metabolic activities of the body. Among the measures of metabolism, the EDR furnishes a response which is sensitive to changes in energy arousal.

From the work of Freeman, five hypotheses concerning the EDR and various psychological situations were derived. Each of the five situations dealt with the manner in which energy would be aroused or discharged in the integrated organism.

Since energy may be dissipated in various nonadaptive ways during these experiments, obtaining an inclusive energy index is not an easy task (see pp. 19-20). Changes in task demand may be reflected in either or both EDR or performance changes. Inasmuch as no provision was made in these experiments for tight control of one or the other (e.g. pacing of the task to control performance), it was necessary to substitute statistical control for experimental control. Either the EDR or the performance measure could be regressed. It was decided to regress or correct the EDR scores for the level of performance to obtain an energy index which would relate to the situational conditions of each experiment.

The first experiment dealt with overmobilization. When the organism is driven to very high energy levels, his performance should deteriorate. Unfortunately, in this investigation, the stress test was not one which adequately caused mobilization. Few of the subjects appeared highly concerned about their inability to master a finger maze.

In the second experiment which considered the energy cost of shifting between tasks, only one section of the graph (see p. 59) of regressed EDR means versus the number of shifts possessed the expected slope. This section of the graph dealt with an increase from thirty-two to forty-eight shifts and followed a simpler section containing only three shifts. Hence this section not only was one of increasing difficulty, but also one in which adaptation had occurred and neuromuscular residuals were allowed to accumulate. The positive slope of the EDR curve under these conditions suggested that the postulated relationship between EDR and shifts of set might hold when an habituation session to allay apprehensive mobilization is used.

Another finding of the shift of sets experiment revealed an inadequacy in counterbalanced order experimental designs. Evidently, progressing from few shifts to many shifts and allowing the residual to accumulate is not neuromuscularly the inverse of progressing from many to few shifts. In this latter case, the subjects discharged rather than mobilized energy and their over-all performance score was faster than under the first procedure.

In the distraction experiment, there was no counterbalanced design and the residuals were permitted to accumulate under four intensity loads of the interfering tasks. A covariance analysis added little to the pattern of significant variables. Both the EDR and the performance indicator differed significantly only on the variable of levels of intensity of the interfering tasks.

It was suggested that, since the control and the distraction groups worked under an expectancy set, the lack of a significant difference between the distraction and the control groups may be due to the additional task loading for the distraction groups. Extrapolating from the usual curves of accumulated residuals, there would appear to be an interaction between expectancy set residuals and those of the task.

The results of this investigation were not improved by the covariance technique. The performance and EDR scores were not covariant within groups although their means appeared to be related. This lack of covariance, it was felt, was due to personality factors having to do with ways of meeting distractive situations. Suggestions regarding further research on the relationship of energy arousal and distraction were presented.

In the ego-involvement experiment the stress was the subject's feelings concerning himself. Although the subjects could not judge their own degrees of ego-involvement accurately, evidently this task was not too difficult for clinical psychology trainees. The relationship between degrees of ego-involvement and EDR changes was significantly different from zero but low, eta equalling .34. The shape of the relationship, a function of the type of scale used for judging degrees of ego-involvement, appeared to be _U_-shaped.

This significant relationship may have implications in value and attitude scaling.

The perception and EDR experiment dealt with changes in the EDR due to completed and noncompleted perceptual sets. The lack of an appreciable degree of involvement and the counter-balanced design, either singly or acting in combination, could have been enough to eradicate such differences as might have been expected.

Energetics experiments require much more closely fitting, and possibly simpler, experimental designs. Counter-balanced orders and sequences are not necessarily equal in their discharge or accumulation rates for experiments in energetics.

One of the great pressing needs in energetics is knowledge of personality variables. The modes that the normal individual uses as reactions to everyday stimuli are largely unknown. These personal and culturally instilled habits expressed in energetic terms for the normal individual (see p. 26) would greatly aid in the design of these experiments by giving some indication of what to control for. It is hoped that some of these variables will be discovered and impetus given this line of research through the type of investigations described here.

In summary, of five experiments derived from Freeman's notions of energetics, in one, ego-involvements and the EDR, evidence was obtained to support the specific hypothesis of that experiment. The distraction and EDR experiment results as well as the shifts of sets and EDR results supported their specific hypotheses in part. The failure to obtain positive results in the remaining two experiments apparently was due to the failure to provide meaningful tasks in which the subject could become involved. In brief, studies concerned with energetics must be built around realistic situations and planned especially well.

CHAPTER XI

SUMMARY AND CONCLUSIONS

System theory was presented as a framework which might possibly lead to unifying principles both within psychology and between psychology and the physical and biological sciences. The key notion in such a theory is that it deals with energy exchanges between systems or sub-systems.

G. L. Freeman's theory of energetics, based on the broadened notion of homeostasis, was presented as an open system theory for psychology. To help explain the functionally integrated response system, Freeman makes use of neuromuscular homeostasis. This homeostatic system mediates the symbolic process involved in learning, motivation, reasoning, and the ego functions by means of neuromuscular sets.

From Freeman's work experiments were derived which dealt with the relationship of energy levels as measured by the EDR with various performances.

In the stress and EDR experiment it was hypothesized that, if subjects were overmobilized, their performance would deteriorate. Blindfolded subjects were required to learn a finger maze under instructions that maze learning was highly related to intelligence. When the maze was correctly traced once, a barrier was inserted on the next two trials in a correct alley near the terminus. It was expected that maze learning ability would disintegrate on the subsequent trials.

Unfortunately, the situation did not produce stress, much less overmobilization. There was no significant deterioration of response.

The shifts of set experiment tested the hypothesis that significantly more energy should be expended in performing simple arithmetic problems with the operations of adding, subtracting, multiplying, and dividing scrambled rather than in uniform groups of similar operations. Three sheets containing identical problems were prepared: sheet A contained three shifts between operations, sheet B thirty-two shifts, and sheet C forty-eight shifts. Two groups of subjects were used in two orders, ABC and CBA, in an attempt to counterbalance fatigue, practice, and habituation effects.

Only in part of the experiment for order ABC did the regressed EDR curve have the expected slope. In this case the shifts increased from thirty-two to forty-eight and neuromuscular residuals and the warm-up effects had been allowed to accumulate. These data suggested that subjects require an adaptation period to allay apprehensive arousal before changes due to shifts of set can be demonstrated.

The problems were performed at a faster rate in order CBA than those in order ABC. The means and sigmas for this order suggest that counterbalanced experimental designs are not necessarily equal in effect, neuromuscularly, in both directions.

In the distraction and EDR experiment it was hypothesized that regressed EDR scores would show significant differences due to degrees of distraction. Subjects were required to perform successive addition problems while either voice or typing interference was presented at five levels of intensity. A control group was given instructions to expect the noise but received none while working the problems.

The results indicated that there were no significant differences among the three groups, the two task groups and the control group. It was felt that the expectancy set of the control group and the work load, plus the accumulation of neuromuscular effects, could explain the lack of difference between the control and the interfering task groups.

Intensity levels of the interfering task were significant and in the direction expected. This was interpreted as positive results regarding the hypothesis that there should be energy increases under distraction. On the other hand, a covariance analysis added little to the pattern of significant variables. It was suggested that personality variables having to do with the manner in which distraction is responded to were responsible for this lack of covariance. Suggestions for further research in the relationship of energy arousal and degrees of distraction were presented.

In the ego-involvement and EDR experiment a nondirective interview over twelve items from an adjustment inventory was carried out. The subject and two clinical psychology trainees used a five-point scale to classify the degree of ego-involvement for each item. A significant relationship between ego-involvement and EDR was hypothesized.

The results were not significant for the subjects' classifications. This was interpreted as part of the ego-involvement syndrome. On the other hand, an eta of .34 was obtained for the relationship between EDR and clinicians' estimates of degree of involvement. The eta of .34 was significantly different from zero, and the shape of the relationship, a function of the type of ego-involvement rating scale, was _U_-shaped, as expected.

These results suggest that changes in EDR might be used as the physical continuum along which to construct attitude and value scales.

Perception and the EDR was the final experiment in this series. It was hypothesized that there would be significant differences in EDR between completed and noncompleted perceptual tasks. It was felt that the lack of involvement and the counterbalanced design could have operated to obscure the expected results.

In general, of the five experiments, the ego-involvement experiment fulfilled its specific hypothesis. The distraction and the EDR experiment and the shifts of set experiments fulfilled part of the specific hypotheses of their experiments.

In addition, with hindsight, it would appear that the explanation of the failure to obtain positive results in the remaining two experiments as well as parts of the distraction and shifts of set experiments can be marshalled in support of the principles of energetics presented. In the discussion for each experiment specific analyses and recommendations for future experimentation were presented. In brief, experiments in energetics require realistic and careful planning when considering the experimental situation and task.

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APPENDIX

Table 22

EDR Differences and Error Changes for the Stress and EDR Experiment

Subject	Barrier 1		Barrier 2	
	Error change	EDR change	Error change	EDR change
1	-2*	168**	-2	48
2	-1	48	1	54
3	-1	-2	5	120
4	2	23	7	71
5	0	25	4	6
6	-1	-17	1	44
7	-2	41	1	21
8	1	65	1	59
9	-1	133	1	-22
10	14	22	1	34
11	14	31	4	-36
12	3	-5	-2	40
13	-1	29	3	31
14	-1	79	0	27
15	27	59	18	285
16	0	-66	0	38
17	0	38	0	15
18	0	0	-1	11
19	0	13	4	41
20	10	-35	4	21
21	2	41	106	-48

*Minus means more errors before block.

**All log EDR difference scores have been multiplied by 100.

Table 23

Log EDR Response Scores for the Shifts of Set Experiment

Order	Subject	Sheet A	Sheet B	Sheet C	Mean
	1	4140*	4101	4043	4095
	2	4056	4353	4283	4231
ABC	3	4197	4197	4214	4203
	4	4148	4025	4152	4108
	5	4276	4342	4330	4136
	6	4246	4378	4392	4339
	7	4244	4122	4180	4182
ABC	8	4122	4189	4090	4134
	9	4019	3978	3880	3959
	10	4320	4383	4330	4344
	11	4161	4152	4142	4142
	12	3898	3948	4044	3963
CBA	13	4214	4246	4276	4245
	14	4056	4068	4101	4075
	15	3978	4005	3992	3992
	16	3718	3755	3853	3775
	17	4181	4234	4292	4236
CBA	18	3755	3876	3915	3849
	19	4214	4269	4320	4268
	20	4166	4180	4346	4231

*All log EDR scores have been multiplied by 1,000.

Table 24

Corrected Time Scores for the Shifts of Set Experiment

Order	Subject	Sheet A	Sheet B	Sheet C	Mean
	1	247	238	210	232
	2	344	343	323	337
ABC	3	275	294	265	278
	4	324	332	272	309
	5	252	290	291	278
	6	506	489	498	498
	7	364	430	415	403
ABC	8	243	240	230	238
	9	380	331	336	349
	10	345	347	316	336
	11	146	148	195	163
	12	226	279	290	265
CBA	13	384	470	511	455
	14	365	402	550	439
	15	324	283	354	320
	16	351	293	282	309
	17	291	259	239	263
CBA	18	357	262	200	273
	19	276	238	186	233
	20	386	346	270	334

*These data are in seconds.

Table 25

Log EDR Response Scores for the Distraction Experiment

Group	Subject	Noise Level 0	1	2	3	0	Mean
Voice Distraction	1	484*	479	477	478	477	479
	2	411	386	352	349	349	369
	3	406	403	412	401	397	404
	4	406	414	402	397	397	401
	5	416	414	411	407	431	416
	6	391	381	372	367	361	374
	7	402	433	438	437	417	423
	8	397	389	386	383	383	388
	9	391	381	373	369	367	376
	10	394	386	384	382	380	385
Typing Distraction	11	475	479	479	479	475	477
	12	415	406	406	398	399	405
	13	488	484	479	471	479	480
	14	412	408	414	381	381	399
	15	439	428	431	428	428	431
	16	418	414	410	405	405	410
	17	422	419	415	415	415	417
	18	432	428	424	423	423	426
	19	414	410	407	405	398	407
	20	410	406	397	392	386	398
Control	21	463	464	462	455	452	459
	22	474	475	484	485	479	479
	23	407	434	436	444	433	441
	24	404	415	419	409	397	409
	25	362	351	341	347	333	347
	26	423	406	409	410	410	412
	27	376	375	371	356	333	362
	28	325	392	393	389	380	388
	29	447	453	454	455	454	453
	30	413	416	440	434	429	426

*All log EDR scores have been multiplied by 100.

Table 26

Corrected Time Scores for the Distraction Experiment

Group	Subject	Noise Level 0	1	2	3	0	Mean
Voice Distraction	1	140*	238	182	153	143	171
	2	129	116	146	169	127	137
	3	111	123	129	124	119	123
	4	204	227	185	163	185	193
	5	216	212	304	194	154	196
	6	322	309	317	229	238	283
	7	178	160	182	163	142	165
	8	388	367	285	385	214	328
	9	249	248	321	269	232	264
	10	203	166	143	157	134	161
Typing Distraction	11	189	163	160	159	186	171
	12	237	248	283	290	223	256
	13	129	116	114	98	94	110
	14	338	291	246	256	223	271
	15	142	100	106	105	97	110
	16	148	180	156	170	153	161
	17	289	278	293	229	242	266
	18	183	187	146	148	150	163
	19	165	146	130	122	114	135
	20	174	77	75	76	70	94
Control	21	540	475	264	305	213	359
	22	154	154	198	189	209	181
	23	460	184	195	185	184	243
	24	213	173	133	191	158	174
	25	199	260	384	311	397	310
	26	154	216	172	177	154	175
	27	154	233	245	335	209	335
	28	249	237	248	349	205	258
	29	515	300	223	293	328	332
	30	281	237	237	209	173	227

*These data are in seconds.

Table 27

Average EDR Difference Scores for Each of the Subjects' Response Categories in the Ego-Involvement Experiment

Subject	No	More No than Yes	Can't Say	More Yes than No	Yes
1	193*	148		138	252
2	467	390		383	381
3		188	406	239	332
4	202	157		227	184
5	405		100		187
6	169		157	168	
7	381	576		570	588
8	147	176	78	152	
9	192				
10	153				178
11	235		207		235
12	181	222	135		203
13	61	45		77	
14	287	249	290		266
15	355	364	320	555	
16	552	326		1269	50
17	239	283		220	209
18	87	127		116	179
19	340	360	422		
20	51	80	21	67	21
21	302	319	474		420
22	97	87		434	189
23	-4	1		111	35
24	70	17			70
25	144	142		134	152

*All average EDR difference scores have been multiplied by 100.

Table 28

Average EDR Difference Scores for Each of the Experimenter's Response Categories in the Ego-Involvement Experiment

Subject	No	More No than Yes	Can't Say	More Yes than No	Yes
1	193*	148		214	
2	533	373		479	428
3		195		356	262
4	202	239	152	192	212
5	423	222	570	216	100
6	160		162	157	197
7	334	455	576	444	
8	138	151	150	161	152
9	240		137	160	
10				218	170
11	241	193		216	225
12		265	208	140	170
13		53	47	58	87
14		200	235	283	764
15		168	317	376	509
16	792	477	550	326	863
17	251	182		262	276
18		87		133	179
19		394		306	361
20		113	21	87	17
21	369	133		441	399
22		117	157	88	311
23		-24		-17	72
24		66	-53	50	138
25	134	140		138	42

*All average EDR difference scores have been multiplied by 100.

Table 29

Log EDR Response Scores for All Conditions of the Perception Experiment

Order	Subject	A*	B	C	R_1	R_2	A	B	C	R_1	R_2
Noncompleted-completed	1	436**	424	428	432	420	424	428	428	428	428
	3	440	436	436	436	436	440	440	440	436	436
	5	466	463	466	470	474	466	463	466	470	478
	7	357	357	352	352	352	352	352	346	346	346
	9	397	397	397	401	409	409	405	409	413	416
	11	413	316	424	428	432	440	436	436	440	443
	13	405	409	413	416	420	420	420	409	405	409
	15	420	424	428	428	432	409	413	416	424	428
	17	376	372	376	376	367	367	372	376	362	362
	19	372	372	372	372	372	267	267	267	372	372
Completed-noncompleted	2	357	357	352	352	352	346	346	346	352	352
	4	482	466	460	456	463	453	456	460	442	445
	6	405	393	397	401	401	397	389	393	393	397
	8	346	346	346	340	340	340	340	340	340	340
	10	393	393	393	397	397	376	381	381	385	385
	12	443	440	443	447	451	447	440	436	440	443
	14	381	385	381	385	385	372	376	372	376	376
	16	401	405	401	376	376	367	372	376	352	357
	18	443	440	447	447	451	447	443	443	447	451
	20	409	397	397	405	409	409	405	401	409	413

*A, B, C refer to readings of thirds of work curve, R_1, R_2 to resting level measurements.

**All log EDR scores have been multiplied by 100.

EXPERIMENTERS' CLASSIFICATION CRITERIA FOR THE EGO-INVOLVEMENT EXPERIMENT

The experimenters thought of the rating scale as a continuum of progressive degrees of ego-involvement from No to Yes. The latter presented the highest degree of involvement. In making the classification of the subject's response, attention was paid to what the subject said and the way he said it. The two main features influencing the judgment were the subject's response and his behavior. The following are some examples of subjects' responses and behavior for the various categories:

NO. The subject responded to the question "Does it frighten you when you have to see a doctor about some illness?" with "No, I've always been healthy and haven't had much to do with doctors, but if I were to get sick, he's the man I'd want to see." A response such as this given in a casual and off-hand manner was classified as No.

Another example might be the response to the following ego-involvement question "Do you find it difficult to make contact with members of the opposite sex?" The subject responded "No, that has never been difficult for me. I've been going steady for the past year, and I live in a frat house where we have some social function going on all the time."

MORE NO THAN YES. To the question, "Are you troubled with shyness?" despite the fact that the subject classified his response as No, the experimenters classified his response as More No than Yes since there was some element of doubt in his verbal response. For example, he might have said, "Most of the time I'm able to go up and meet people pretty easily. I think I used to be a little shy in High School, but that has left me pretty much now."

CANNOT SAY. Often times the deciding factor for using this classification category was an element of doubt in the subject's response. For example, to the question, "Are you troubled with shyness?" the subject might respond with "Well, I really cannot say as I think sometimes I meet people easily, but it sure depends on the occasion. Like some nights over at the house I'm in the group singing or going down to the basement, but at other times I guess I sorta hang back."

This category was thought of by the experimenters as a point on a continuum representing a half way mark between the extreme degrees of ego-involvement.

MORE YES THAN NO. Despite the subject's verbal response to a particular ego-involving question, if his behavior was such as to indicate involvement, but no extreme involvement, then this classification was made. For example, to the question, "Has either of your parents criticized you unjustly?" the following response sequence would have been classified this way, "Well, that's hard to say." Starts tapping foot. "What do you mean by criticize?" Runs hand through hair. "I guess all parents do that more or less, don't they?" In this example, both verbal and the motor responses were noted in applying the classification.

YES. This classification was made when the behavior, at least, was indicative of pronounced involvement. Often, however, this was accompanied by a Yes or frank admission that the statement was so. It was seldom, if ever, that the experimenters made any other classification but Yes when the subject indicated that he meant a strong Yes.

For example, an unshaven, unkempt, nervous, and suspicious freshman was asked the question, "Do you consider yourself a rather nervous person?" He shakily marked Yes with the pencil and then said in a tremulous voice, "Yes, and I always have been. My nervousness ruins my grades. I know the stuff the night before, but when I get into the quiz I get cold all over and can't remember half of what I studied." This was considered a Yes response.

It should be pointed out that these classifications are relative to each individual and his responses and his behavior.