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COGNITIVE AND CENTRAL NERVOUS SYSTEM FACTORS IN PSYCHOPHYSICAL JUDGMENT

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

Current thinking concerning perception recognizes the crucial role it plays in man's interaction with the environment and emphasizes the complexity of perceptual processes. The latter emphasis has resulted from at least two sources. The first is the growing realization that any adequate description of human behavior must include concepts involving both internal (organismic) and external (stimulus field) variables. The second, and related tendency, is to view the perceiver as an active contributor to the perceptual process rather than a passive recipient of stimuli. Perception, then, is conceived of as an adaptive process which is highly dependent upon previous experience of the perceiver as well as focal and background stimulus conditions (Helson, 1964) and, of course, the integrity of central nervous system functioning. The present experiment has been framed in this context and will investigate the perceptual process as inferred from heteromodal psychophysical judgments under different stimulus and organismic conditions. The major independent variables involve: (1) three peripheral receptor systems (visual, auditory, vibratory), (2) variations in stimulus conditions (anchor effects), (3) variations in psychological sets (instructions), and (4) variations in central nervous system functioning (intact vs. impaired). To approach the problem area, it is necessary to make a gradual ascent through basic psychological issues related to perception and to anchor it in a psychophysical framework.

Definition of Basic Terms

Let us start by discussing the basic terms used in this study, i.e., perception, discrimination and categorization. According to Gibson (1959, p.457), perception is a "process by which an individual maintains contacts with his environment." This permits recognition and response to the world of objects, places, and events. It serves as a form of adjustment to the environment in which the organism evaluates and classifies the stimuli present; and reacts to them in a differential manner. According to Helson (1964), there are two broad classes of stimuli: stimuli to be approached and stimuli to be avoided. There are also varying degrees of acceptance or rejection as well as a position which is ambivalent or neutral. These three different kinds of responses, i.e., approach, avoidance or neutral, are indicative of the process of discrimination which is the ability of the organism to respond in different ways to different stimuli. To Thurstone (1927), this response which ". . . identifies, distinguishes, discriminates or reacts to stimuli" occurring at any moment, is a discriminal process. The discriminatory behavior, he maintains, may be either psychological, or physiological or both. Razran (1949) points out that this discrimination continuum has more steps in man than in animal. Order is established on the basis of discriminatory response along a stimulus dimension. Discrimination becomes more efficient and finer with the growth of the organism. Gross approach-avoidance behavior no longer acts in an all-or-none manner, but becomes a complex, many-stepped response based on various properties of objects or events. These various perceptions can be thought of as categorizations which gradually begin to elicit differential responses. At a more primitive level the categorization scale might be a dichotomy or a few discreet points; but as the organism grows and learns, the scale is developed through more and more categories which help the organism's adjustment to the environment.

This gradual sophistication of the categorization scale brings newer elements into consideration, especially in relation to the higher mental processes or conceptual functioning. Bruner, Goodnow and Austin (1956) have explained the two different levels of categorization prevalent in psychology.

> One of the principal differences between the two forms of categorization. . . the perceptual on the one hand and conceptual on the other. . . is the immediacy of the attributes by which their fitness to a category is determined. In the

> perceptual sense the relevant attributes are more immediately given by which we judge the categorical identity of an object at least in simple perceptual situations. At the other end the attainment of knowledge about the attributes that are relevant may require a difficult strategy of search....

Classic and Modern Psychophysics

The very idea of categorizing and discriminating implies comparisons. One object or event is compared with another in various forms. Is it similar or different, or is it more or less, or equal? These experiences are scaled along a continuum on the basis of intensity or magnitude. Psychophysics investigates these different continua and tries to explore the relationship between the physical world and the corresponding experienced dimensionality. The stimulus dimension was the primary subject matter of traditional psychophysics and the sensory experiences studied were highly stimulus bound (Titchener, 1927; Cattell, 1892). A controlled series of stimulus presentations and the corresponding responses in the form of quantitative judgments were considered to be standard and very much the same for all members of the population. Various workers (Werner, 1937; Hebb, 1949; Postman and Bruner, 1949; Gibson, 1950; Galanter, 1962), however, have indicated that this is an over-simplification. Galanter states, for example, that psychophysical judgment is a complex outcome of behavior resulting from the stimulus characteristics, its probabilities of occurrences, payoffs, values, motives, expectations of the individuals and the physical and physiological limits of the receptor mechanism. In this way modern psychophysics is concerned with the identification and elucidation of variables which affect the behavior of a person in his judgments, actions and responses. It looks for the underlying laws of behavior showing the invariant response structure that transcends the variations in the impinging stimulation.

The role of the organismic variables in affecting the perceptual processes has been convincingly demonstrated by various studies (Postman and Bruner, 1949; Howes and Solomon, 1951; Kristofferson, 1957; Goldiamond and Hawkins, 1958; Postman, Bruner and Goodman, 1947). Investigating the influence of set on psychophysical judgment, Postman and Bruner (1949) found that the recognition thresholds under the single set condition were lower than those under the dual-set condition. In a similar experiment using tones of particular frequency, Karoly and Isaacson (1956) observed that an inappropriate set has a lower probability of detecting the set-incongruent tone than the control condition.

Other variables being studied, Goldiamond and Hawkins (1958) have illustrated the importance of response-bias in a psychophysical judgment situation. They showed that frequency, familiarity, etc., even when not directly influencing the perception, might impose biases on response probability. Motivation as a potential cognitive variable has been demonstrated by McClelland and Liberman (1949). In this study it was found that subjects were more sensitive to words connoting high achievement-motive than to words presumably less achievement-motivated. Another experiment performed by Bruner and Goodman (1947) demonstrated the influence of value of coins on the perceived size. In their conceptualization of this area Bruner and Goodman have recognized two general classes of determinants refer to physiological properties of the sense organ while the behavioral determinants refer to perceptual activities like values, feelings, wishes, etc.

In another attempt to conceptualize all the potential variables that might influence perceptual activity, Graham (1950) gives us the following schematic representation:

$$R = f(a, b, c, d, \ldots n, \ldots t, \ldots x, y, z)$$

where R = response, or some measured aspect of it
a, b, c, d = aspect of the stimulus
n = number of times the stimulus has been applied to the organism
t = time
x, y, z = internal condition of set, motivation, etc.

Phenomenologically the dimensionalities of perception are not solely bound by the immediate stimulus. The individual's attitudes, values, ways of structuring his experiences, judgments along with the environmental forces represent the mode of adjustment and the interacting behavior.

Implicit in classic psychophysics is consideration of the response as a passive reception and reflection of stimuli; a pure sensory awareness of something or a matter of exteroceptive sensory organization. But there is evidence that all sorts of complex adjustments are going on in the perceptual act, adjusting both to the object focally perceived and to its surroundings (Werner and Wapner, 1952). According to these authors the stimulating object not only involves the receptor and the sensory area of the cortex, but arouses a series of sensori-tonic events involving the organism as a whole. In the process of attending there is muscular contraction including the accommodation of the sense organ. The body position and the motor attitudes facilitate the recognition and aid in the recall of previous sensory experience. The tensions and overflow effects produced by the stimulus-field result in respiratory and circulatory changes accompanying certain position balance, and action. From a similar standpoint, Freeman (1948) considers that human behavior can be expressed as a homeostatic adjusting mechanism maintaining a basic energy level.

Dempsey (1951) also holds that voluntary activity, intrinsic responses and perceptual-cognitive behaviors are a form of homeostatic adjustment to a changing environment. Homeostasis in Dempsey's system represents various levels of complex physiological interaction. For instance, the blood-sugar level is regulated by apparently discreet organs or functions and is the outcome of relatively simple low order integrations. But in an emergency situation the mobilization of the organism involves a complex interaction of chemical, endocrinal, and neural systems. Thus a physiological pooling of many systems is a prime condition for maintaining a steady internal state necessary for the survival of the organism. A similar pooling at the psychological level is hypothesized by Helson (1947), to be concerned with complex perceptual-cognitive functions, that are involved in the adjustment or adaptation of the individual. His main thesis is that a response, perceptual or otherwise, is an adjusting mechanism for the optimum functioning of the organism.

Helson's Adaptation Level Theory

The concept of adaptation originates from physiology (Ruch, 1946) where the decline in the rate of discharge of receptors due to prolonged stimulation is observed. The decay of the sensitivity of the end organs after continued stimulation is termed as the adaptive state. But there is evidence that coincident with the decrement in response of some receptors following repeated stimulation, there is a heightened response on the part of the other receptors. Thus adaptation is as much a sensitizing process as a desensitizing one (Helson, 1964). Adaptation to red color makes one more responsive to green; adapting to dark makes one more sensitive to light. It is therefore a two-way process involving heightened as well as lowered performance of the sensori-motor system. On the one hand we see a phenomenon like homeostasis, striving toward equilibrium or a more or less steady state, and at the same time we see that the organism strives for variety, change and novelty.

Helson (1964) suggests that impulse for action comes not from conditions leading to steady state of the organism but rather from the disparity between the stimulation and the prevailing adaptation level. Equilibrium states represent the reference point from which behavior is measured, predicted and understood. This does not imply that the goal of behavior is a state of equilibrium. The adaptation level is a neutral point or origin to which gradients of stimulation are referable. Even in an apparently consistent environment the organism is in a continual movement characterized by a flux of stimulation changing from moment to moment. Its stability is a dynamic, kinetic equilibrium. There is no perfect balance between the building and breaking processes; rather it is a range over which the organism functions. The available range of steady states is relatively greater at the behavioral level than at the physiological level. However, this concept of adaptation level described as adjustment of internal to external relations needs to be stated in a more specific manner and in operational terms to be of experimental use.

The adaptation level theory of Helson is a general principle to account for different levels of perceptual events from simple sensory responses to complex social behavior. It offers a mathematical model allowing prediction and empirical verification of perceptual behavior (Helson, 1947). Adaptation level is the weighted mean of all the stimuli affecting behavior temporally or statially, as figure or ground. It is a quantitative operational concept for handling varied response or adjustment of the organism to the conditions confronting him. The principle recognizes that, besides the stimulus manifold, the internal organismic factors affect the perceptual dimension in keeping with the states of needs, values, and feelings of the individuals. The total situation is a functional process; a resulting process of the interactive forces of both internal and external factors.

Helson first arrived at the adaptation level idea in studies of color constancy conversion, and adaptation (Helson, 1938). An object with a reflectance level above that of its background took on the hue of the illuminant. An object of about the same reflectance level as its background tended to be seen in its natural color. This general conclusion concerning color phenomenon would occur when the object viewed was at the adaptation level at that moment and that the adaptation level was a function of many stimulus conditions. Extending his principle to other perceptual situations, Helson (1948) generalized the applicability of the adaptation level (AL) concept to judgment of lifted weights. On the basis of Fechnerian function, AL, in relation to the psychophysical responses, is predicted to be a geometric mean of the stimuli used. In a more general situation besides the series or focal stimuli being judged, there are other stimuli that influence the adaptation level. These are background stimuli and other contextual stimuli. It is known that sometimes experiences previous to the experiment have appreciable effect on the performance. To have a comprehensive reference for the AL and to allow for failures of prediction, the pre-experimental residual effects were incorporated in the theory (Michels and

Helson, 1949). Thus the chief determinants of the AL in an experimental setup are (a) the residual effect of all relevant previous experiences, (b) the contextual stimuli and (c) the experimental or focal stimuli. On this the equation is:

$$A_e = A_p^m A_c^n S_i^e$$

where A_p = the AL at the time the experiment begins (previous experience).
A_c = the AL contributed by the contextual stimuli only.
S_i = a geometric mean of the stimuli being judged in the experiment.
A_e = the resulting AL from all three above sources.

The powers m, n, and e are the weights applied to the respective sources and m+n+e = 1. The above schematic model defines the total context from which psychophysical judgments are made. The task now is to identify the variables involved.

Variables Affecting Psychophysical Judgment

Psychophysical judgments such as perception of size, weight, brightness, etc., are affected by various factors like frequency of the stimulus, latency, order of presentation, nature of instruction, and protocol of the scaling categories. For example, two fundamental classes of judgmental continua has been suggested by Stevens (1957) on the basis of the distinction between perception of intensity and perception of quality. The first class, which is called prothetic, includes magnitudes like heaviness, loudness, brightness. These are based on the assumption that the underlying mechanism is additive, the assumption being that the same receptors are involved and as the perceived magnitude increases excitation is added to excitation involving higher frequency of firing in greater number of nerve fibres. In the second class, which is called metathetic, are included such qualities as pitch, visual position, inclination based on the assumption that a substitutive mechanism is at work at the physiological level. This distinction rests on assumed differences in the form of stimulus-judgment functions. Continua in the first class are usually non-linear magnitude scales while continua in the second class are generally linear. "On all prothetic continua the magnitude scale is a power function, the discriminability scale (jnd) approximates a logarithmic function, and the category scale assumes a form intermediate between the two." (Stevens, 1961, p.9).

However, there is some evidence showing that curves are affected more by conditions of judgment than by the difference between so-called metathetic and prothetic dimensions (Helson, 1964). Judgment of loudness which involves magnitudes, is affected by the composition of the variables judged and by standards or anchors, and judgments of pitch, which involve quality, also are affected in the same way by these factors (Garner, 1954). Christman (1954) reported a shift in pitch following prolonged stimulation with pure tones. He observed that the pitch of the standard tone is lowered by the satiating tone of higher frequency than the standard and is raised by satiating tones of lower frequency. The magnitude of the effect varied directly with the duration of the satiating tones and inversely with the time between satiating and testing. In a similar situation where ratio judgments had to be made, it was found that the effect of changing the way in which the ratio judgments are expressed made the curve relating the psychological scale values to physical measurement more positively accelerated and changed from a predominantly underestimation of physical values to a predominantly overestimation (Baker and Dudek, 1955). The influence of context on fractionation has been observed by the fact that the stimulus judged as half of a standard depends not only on the standard weight but also on the series stimuli from which the subject must pick the half weight (Engen and Tulunay, 1957).

Anchors or backgrounds usually exert even greater effects of individual stimuli than do contextual stimuli since the latter differ less from the stimuli being judged (Helson, 1964). In bisecting the lightness interval between a white and a black stimulus it was found that the reflectance of the background against which the end stimuli were viewed as exerting a decisive effect on the stimulus judged to be halfway between them. Bevan, Barker, and Prichard (1963) have shown that the form of ratio scales depend upon temporal and spatial order of presentation stimulus. They concluded that there is an upward bowing curve with ascending order of weights and a downward bowing curve with descending order of weights. Guilford (1954), using the method of paired comparisons to judge seven stimulus weights against each stimulus serving as a standard, found that bowing depends on the position of the standard.

However, comparing the two major methods of judgment and the corresponding scales, Torgerson (1960) feels that both magnitude and category scales are useful and they reflect more or less directly the two standard ways of regarding and using the number or quantity expressed in ratios or differences. Any scaling procedure expressing the relation between R and S can be arbitrarily specified and, according to the choice made, S = f(I) will be found to be either a power function or a logarithmic function. Also, these two psychophysical laws do not reflect empirical differences between the scaling procedures but, conventional differences in the assumptions made when interpreting these procedures.

From a logical and physical point of view, identical stimuli are equal; yet they do not always appear to be so in perception, for if subjects are asked to judge identical sounds, weights, brightness, temporal intervals, and so on, they are usually perceived to be different when presented successively. Mere differences in position also are sufficient to make identical objects appear different. Effects due to order of stimuli are known as time-order errors (Guilford, 1954). The second stimulus is likely to be judged greater than the first. When the point of subjective equality (PSE) is less than the standard (S) there is said to be a negative time-order error (TOE), and when greater, a positive TOE. A negative TOE indicates overestimation and a positive TOE indicates underestimation of the standard stimulus. Since PSE represents the value of stimulus evoking an equality or indifferent response, PSE and AL are identical (Helson, 1964).

TOE is not just a unique phenomenon in a successive presentation of the stimulus or the time between the two stimuli, but it is also observed with the method of single stimuli where stimuli are judged without reference to an external standard. In such cases the central stimulus of the series is not judged to be the mean or median of the stimulus distribution. However, both positive and negative TOE have been found in a psychophysical judgment situation in different sense modalities. Based on the weighted log mean definition of AL it is obvious that the psychophysical relationship between the stimulus series and the response would produce a negative bias in TOE which is usually obtained in lifted weight judgments (Helson, 1964).

If the value of AL or PSE is less than the standard, the judgment of the series stimuli shows a greater probability of heavier responses (in judgment of weight lifting) and if PSE is greater than the standard, there will be a greater probability of lighter responses. Parducci (1959) obtained more judgments of a larger category when the stimuli had a positively skewed distribution.

The shape then of the psychometric curve depends on many factors, e.g., on the stimuli being judged, the task given, the psychophysical method, the method of treating the experimental data, the position of the adaptation level, and so on. The following are some of the chief types of stimulus-response relationships (Helson, 1964, p.189):

> 1. When equally spaced stimuli give rise to equally spaced judgments throughout the stimulus range a straight line fits the data. This is something that seldom happens and usually over restricted ranges of the stimulus continuum.
>
> 2. If changes in magnitude of 'small' stimuli give rise to greater changes in judgment than do equal changes in larger stimuli, negatively accelerated curves fit the data. Such curve may be made linear by taking the log of the stimuli. These curves show spreading of judgments at the low end of the stimulus range and assimilation at the high end.
>
> 3. If differences in stimuli at the low end of the continuum are less well discriminated than are similar differences at the high end, positively accelerated functions fit this case. Judgment at the low end of the stimulus range are bunched while those in the medium and high ranges are spread out. Power functions of their related log-log inverse, being less than unity for negatively accelerated curves, greater than unity for positively accelerated curves, and unity for all linear functions.
>
> 4. When judgments are bunched at both low and high ends of the stimulus continuum but spread out in the intermediate range, S-shaped or ogive curves may furnish good fits to such data. This type of curve also is found when frequencies of responses are plotted as percentages because of the limiting values 0 and 100 percent. The method of constant stimuli with the data plotted as percentages yields ogive curves.

In a typical psychophysical situation it is assumed that all effects of stimulation, past as well as present, are pooled to form a single level with respect to given classes of stimuli. Evidence for pooling comes from many different sources. With visual stimulus and lifted weights the adaptation level has been shown to be a function of the series and background stimuli, changes in one or the other bringing about the changes in the level (Helson, 1947, 1948; Michels and Helson, 1949). Similarly judgments of the sound intensities have been shown to be the functions of series and preceding stimuli (Rogers, 1941). Under some conditions, Johnson (1949) has shown that previously experienced stimuli have considerable effects on the adaptation level. Even stimuli which are not consciously perceived have been shown to exert effects on judgments as detected by galvanic skin response (McCleary and Lazarus, 1949). Black and Bevan (1960) also suggest that the organism may incorporate subliminal stimuli and the absolute threshold of the traditional psychophysics is not the limiting value in the formation of norms underlying judgment. Helson and Nash (1960) showed a differential effect of the anchor on judgment depending on the relationship between the magnitude of the anchor and the series stimuli. They observed that a 900 gram anchor affected the AL in relation to a 100-300 gram series more apparently than in relation to 400-600 gram series. They concluded that the anchor farther from the series affect the AL and hence the judgment more than does the anchor nearer the series. Postman and Miller (1945) found that an interval was perceived to be longer preceded by an anchor well below the series stimuli than when presented without an anchor.

Conceptual Behavior and Psychophysical Judgment

The above studies mostly deal with a single sensory modality which is the traditional psychophysical approach of isolating a single dependent variable. Without taking issue with the practice, it is felt that at some point in time an attempt must be made to integrate the function of the sensory modalities as they relate to conceptual behavior, in this case, judgment. This is thought to be possible within a neuropsychological framework (Hebb, 1949) which places emphasis on the common physiological concomitants of conceptual activity. In this light it may be assumed that psychological judgments made through different sensory modalities are certainly not independent of one another but may act (use common cell assemblies or phase circuits) in similar ways.

Most of our everyday judgments as well as those made in an experimental situation generally act in a resultant or interactive manner as far as the sensory modalities are concerned. Several experimental work in this area have demonstrated these interactive effects of one sense modality on another (Klient, 1937, 1938; Werner, Wapner, and Chandler, 1951; Behar and Bevan, 1961; Bevan, 1965).

The problems resulting from the interaetion can be seen in a study by Brown (1953). In a weight-lifting task he used a relevant anchor (anchor identical in look with the series) and an irrelevant anchor (a tray of equal weight). The results indicated that the irrelevant anchor produced less effect on the series judgments. In the light of the previous discussion it may be expected that the judgment situation involved in an interactive process due to the participation of the visual modality along with the tactual-kinesthetic modalities. Which modality is contributing to this effect of ignoring the physical stimulus here? Brown does not seem to recognize the possibility of this interactive mechanism.

An analysis of the entire area of weight judgment is also seen as an instance of a complex interactive involvement of more than one sensory modality. In the most simple judgment task of weight-lifting, one could claim interaction between the kinesthetic and tactual senses (Buchanan, 1953). It is apparent then, in the area of judgment, that there is a need to separate the task of judging and at the same time provide a means of relating the separate "pure" functions to the molar behavior of the functioning. One study in this direction is that of Behar and Bevan (1961) who gave a most complete consideration of the visual and auditory modes in judgment of duration. They used judgments of time as their dependent measure. The first situation concerned the length of the time was presented by a visual stimulus (light). An anchor stimulus of time was then introduced via the auditory mode, *i. e.*, a noise was presented for the anchor period of time. In the second situation the series stimuli mode was reversed, *i. e.*, the judgments were made on auditory stimuli when the anchor presented was visual in nature.

The results showed that the use of heteromodal anchor did affect in a significant manner the series judgments. The use of a visual mode anchor affected the judgments involving the auditory series and also the auditory anchor had a significant effect on the visual series. This work demonstrated that there are common properties of judgments of auditory and visual dimensions, pointing up the conceptual nature of all dimensions. Furthermore:

> "The demonstration of hetermodal anchor-effects indicates that the modality is not a limiting factor in the identification of relevant input for pooling. It also supports the view that sensory data, so long attributed to the operation of peripheral mechanism, reflect a complex judgmental process, largely central in character. Consistent with this interpretation is the fact that the anchor-effects in the two modalities studied, vision and hearing, were highly similar." (Behar and Bevan, 1961, p. 26).

Since correlations between anchor-effects among individuals are not presented, their study does not provide direct evidence for the existence of the central mediating mechanism, but is viewed as providing indirect support for such a conception. The question may be asked, then, is there a central mechanism (attributed to a part of the brain beyond the projection areas) which decodes the signal, interprets and abstracts it in a manner unique to the individual? Is it possible that there is a generalized and consistent scaling behavior expressed in psychophysical judgments that transcends various sensory modes?

One aspect of the present investigation is to attempt to answer these questions by exploring anchor-effects in three different sense modalities of the same individual. The interest is in the comparison of the dynamic characteristics of these three senses, their interrelationship. Could there be a consistency of the anchor-effect across the modalities leading to a general adaptation level concept on a centralintegral basis? Can one predict this psychophysical behavior from one sense to another?

The Central Nervous System and Adaptation Level

A second aspect of the study is concerned with variation in central nervous system (CNS) functioning in relation to psychophysical judgment. In the recent literature there is a trend to use the AL concept in psychopathological studies (Lhamon and Goldstone, 1956; Boardman and Goldstone, 1962; Boardman et al., 1962, 1964; Salinzer, 1957; Sanders and Pacht, 1957; Webster et al., 1962; Weinstein et al., 1958; Wright et al., 1962). Most of the studies done in this direction are limited to psychosis and psychoneurosis and do not include diseases of the central nervous system. Studies of brain-damaged subjects, using the adaptation level paradigm, might throw some new light in the understanding of the role of CNS in psychophysical judgment.

There is a definite difference in behavior or response pattern between the brain-damaged and non-brain-damaged individuals. But it is not easy to identify the individual variables affecting such behavior differences (Reitan, 1962). One of the approaches is to assume a localized center in the brain for each different function. Any lesion or disease of any of these regions would thus lead to a specific deficit in functioning. Evidence of this approach comes from such studies as Jasper and Rasmussen (1958), Neilsen (1951, 1958), Olds (1958), Penfield (1958), Penfield and Milner (1957), and Reitan (1955). These studies have shown that characteristic behaviors are associated with specific parts of the brain. On the other hand, there are findings which speak against the strict localization of specific function. Semmes, Weinstein, Ghent and Teuber (1960), Roberts (1958), Lilly (1958) observed that typical motor and sensory areas are not as clearly differentiated as previously thought. Wolf, Chapman, Thetford, Berlin and Guthrie (1958) have stated that the disturbance of the high order functions is more related to the amount of tissue destroyed than to its specific location.

A holistic or organismic conception of brain-behavior relationship is represented by Goldstein (1942), Magoun (1958). These workers consider the brain to operate as a totality in terms of affecting the behavior. The behavior observed in cases of brain damage is not due to specific center being involved or destroyed but rather due to the total effect upon the organism. Impairment of psychological functioning is due to a breakdown of, or disturbance in, intracranial organization and patterning. Goldstein (1943) considers that pathological behavior is manifested in the form of disorganization in the response. The destruction of one or another subsystem of the organism gives rise to various changes in behavior indicating how these subsystems or mechanisms of behavior are interrelated.

The changes observed in patients with brain lesions are manifold involving both physical and mental aspects of life. The way we deal with the world around us is predicted upon the proper interpretation of the information afforded us by our various sensory receptor systems. We are in the continual process of making judgments involving time, space and mass in terms of standard physical units ascribed to them. Gross disruptions in the ability to make veridical judgments related to the physical dimensions imply the clinical evidence of impaired functioning. The brain-damaged person is generally considered to involve the impairment of normal conceptual and judgmental processes (Morgan, 1965). Previous studies have suggested that the psychological deficits observed in subjects with brain lesions may be related to the deficiencies in adjusting mechanism and disturbances in perceptual processes (Hunt and Cofer, 1944; Goldstein, 1942; Neilsen, 1951; Meyer, 1957). Goldstein, in his classic work with the brain injured soldiers, was one of the first to demonstrate the deficiencies of shifting set at the perceptual-conceptual level. This "lack of shifting" is one of the primary indicants of the "concrete attitude". At this level of functioning the person is unable to transcend the immediate stimuli present; he is unable to shift to a higher level where the stimuli fall into classes or categories of which the immediate stimuli are only examples. Studies involving temporal discrimination in several sense modalities have demonstrated deficits in the behavior of the individual with cerebral lesion (Ax and Colley, 1955; Parsons and Huse, 1958; Parsons and Gottlieb, 1960). It has been noted that the routine clinical approach has placed an emphasis upon the use of global or omnibus examination techniques looking for a gross psychological characteristics indicating the organic brain damage (Klebanoff, et al., 1954). It seems that a more profitable line of research in this direction would be to know about the less complex psychophysical behavior like perception of color, brightness, time and the like (Sperry, 1952).

In the above context the present study will be concerned with the conceptual deficit as it pertains to the psychophysical judgment situation. If normal perceptual-cognitive behavior is thought to reflect a central, inter-dependent mechanism then one might assume some degree of neural organization in the process. If on the other hand we conceive of brain injury as resulting in some degree of disorganization of cognitive processes, then we might expect differential performances.

Statement of the Problem

As stated earlier, the main purpose of this study is to investigate the consistency of response to sensory input under different stimulus and organismic conditions. In the first part of the experiment the correlations among the anchor effects and the effects of psychophysical set as regards the relevancy of the anchor are the major areas to be studied.

The effects of anchors on scaling behavior is an established empirical fact (Rogers, 1941; Helson, 1947). An intermodality correlation is predicted based on the assumption that a central regulative or control mechanism is involved in the separate sense modality functions. The possible existence of such a mechanism has been discussed extensively in recent psychophysiological research (Shakow, 1964; Pribram, 1963; Hebb, 1955). The work of Behar and Bevan (1961) has also strongly suggested such a central mechanism in the modulation of vision and hearing. However, they made no direct test of this hypothesis. The present experiment is designed, then, to provide a more direct test of the postulated central mediating mechanism through examining the consistency of the psychophysical behaviors within and between individuals. It is hypothesized that:

> Hypothesis I. There will be significant correlations among the anchor effect produced in the various sensory modalities.

Lack of correlation among intermodal anchor effects are expected as a reflection of disorganization and lack of co-ordination at the cortical level. From this standpoint it is proposed that:

> Hypothesis II. There is a lower correlation among the anchor effects of various sensory modes in brain-damaged group compared to non-brain-damaged group.

Various aspects of the stimulus situation determine the extent of the anchor effect on the psychophysical judgment. For example, the position of the anchor in relation to the focal stimuli, the magnitude of the anchor stimulus, the sensory modes involved (Postman and Miller, 1945; Goldstone, Boardman, and Lhamon, 1959). One of the most interesting aspects of the stimulus situation is the degree to which the psychological set of the subject, as regards relevancy or irrelevancy of the anchor stimulus, may affect his psychophysical judgments. Brown's (1953) experiment provided results which suggest that such a set may have considerable effect. In his experiment the subject was asked to lift a tray of weights during a series of judgments. This tray was the same weight as the anchor stimulus, but was not in any obvious way, related to the experimental task. Even though the tray was the same objective weight as the anchor stimulus, the effect on the series judgment was significantly less. One interpretation of these findings is in terms of psychological set to perceive and its effect on series judgments, i.e., anchor stimuli perceived as relevant have a greater effect than anchor stimuli perceived as irrelevant. However, before such a generalization can be accepted, certain difficulties in Brown's experimental design must be noted. In his experiment "set" as to relevancy of the tray stimulus was affected by two variables: (1) the instructional set (the subject was asked to move the apparently irrelevant tray for the experimenter), and (2) the use of the visual mode in the identification of the irrelevant anchor (the tray) whereas the series weights being judged were not visible. The introduction of the visual cues here is viewed as a confounding factor in the tactual-kinesthetic identification of the relevant or irrelevant anchors.

A more convincing demonstration of the role of psychological set would be to test apparently irrelevant anchor effects within the same modality, i.e., where both anchor and series judgments are within the same modality, and the relevancy of the anchor stimulus is manipulated by the instructional set only. If instructions are given to ignore the anchor or to be indifferent to it the anchor effect should be diminished. Thus, the specific hypothesis to be tested is:

> Hypothesis III. An instruction induced set to ignore the anchor stimulus reduces the effect of the apparent physical magnitude of the anchor.

The concept of a central control mechanism can also be related to a notion general integrity of brain function. There is ample reason to believe, as noted previously in this chapter, that just as performance on other cognitive tasks are impaired in the cases of brain injury, judgments of a psychophysical nature would also be affected. This impairment would be reflected in terms of differential effects of the anchor as well as to changes in the intermodality correlation.

This differential anchor effect is predicted on the assumption that the brain-damaged individual has difficulty in assuming a new set and shifting sets, as well as disturbances in figure-ground relationships (Goldstein, 1942). The focal and background aspect of the stimulus-field is considered analogous to a figure-ground relationship; the background stimuli (anchor) being less differentiated by the brain-damaged individual, should exert relatively greater influence on the judgment in the brain-damaged subjects compared to controls.

> Hypothesis IV. The brain-damaged individual is not able to ignore the anchor stimulus (as required by instruction) as effectively

as the controls.

The greater reactivity to background stimuli as well as defects in the structural organizing processes associated with focal stimuli are seen as explanations of the lack of co-ordination and reflection of disorganization at the cortical level. From this rationale one can also hypothesize the differential effect of brain injury between the hemispheres of the brain, the hemisphere with the greatest structural deficiency will result in having less stable reference points for the focal stimuli. Other localized deficits may also lead to differential effects in that specific structures are affected which are related to specific sense modalities. In this context the following specific hypotheses were formulated:

Hypothesis V. The anchor effect is significantly greater in the brain-damaged group than in the non-brain-damaged groups.

Hypothesis VI. There are differential anchor effects between the right and left hemisphere stimulations in brain-damaged subjects when the lesion is lateralized.

CHAPTER II

METHOD

The purpose of the experiment was to study the effect of the anchor stimuli on scaling behavior across different sense modalities. A magnitude judgment on three prothetic continua (Stevens, 1955) to get a psychometric profile (function) was utilized as a response variable. The following independent variables were involved in the situation:

1. Sense modalities: auditory, visual and vibratory touch
2. Anchor stimuli: one in each modality
3. Psychological set: instructions
4. Population variable: brain-damaged and non-brain-damaged

Subjects

There were three groups of subjects: (1) sixteen hospitalized brain-damaged patients, (2) eight non-brain-damaged hospitalized patients, and (3) eight non-brain-damaged, non-patient individuals. Group 3 was included in order to establish that any experimental effects found in the patient group could not be attributed to hospitalization per se.

The patients were selected from the University and Veterans Administration Hospitals of Oklahoma City. Non-patient non-brain-damaged subjects were selected from the hospital personnel and medical students. Selection of the patients with brain damage was established by means of neurological examination or by history of surgical intervention. The criteria for inclusion of patients in the brain-damaged group consisted of the presence of a brain tumor or a previous operation for this condition; cerebral aneurysm; cerebral vascular accident with subsequent positive neurological findings; cerebral abscess; Korsakoff's syndrome; or cortical atrophy such as Alzheimer and Pick's disease. Seizures alone, even if accompanied by an abnormal EEG, were not considered as sufficient evidence of cortical damage. The criteria for inclusion of subjects in the non-brain-damaged group consisted of a medical history free of the following: severe head injury, prolonged unconsciousness, seizures, cerebral vascular accident, blood dyscrasias, pernicious anemia, long-standing and uncontrolled hypertension, chronic and severe endocrine disturbances. Patients with multiple sclerosis, CNS syphillis and Parkinsonism were not utilized. All patients were evaluated by the neurologist of the hospital. Mean age and education were matched for the brain-damaged and non-brain-damaged groups. Mean age for brain-damaged group was 48.8 years and for non-brain-damaged group was 46.9 years. The 't' test between the two was not significant ($p > .05$). Mean education for brain-damaged group was 10.3 years and for non-brain-damaged group was 11.3 years. Education difference was not significant ($p > .05$) between the two groups. Descriptive data of the two groups of subjects are presented in Table 1 and 2.

Table 1

Descriptive data for non-brain-damaged subjects

Diagnosis	Age	Education
1. Non-patient Control	26	17
2. Non-patient Control	46	16
3. Non-patient Control	57	12
4. Non-patient Control	42	13
5. Non-patient Control	51	10
6. Non-patient Control	32	14
7. Non-patient Control	48	9
8. Non-patient Control	39	10
9. PN	42	10
10. RF	46	12
11. GI	52	9
12. D	58	13
13. GI	71	8
14. GI	63	12
15. H	33	8
16. A	44	8

PN Peripheral Neuropathy

RF Rheumatic fever

GI Gastro-Intestinal disorder

D Dermatitis

H Hypertension

A Arthritis

Table 2

Descriptive data for brain-damaged subjects

S no.	Diagnosis[1]	Location[2]	Age	Education
17.	DD	BiFTP	44	7
18.	Tu	LPO	47	10
19.	CVA	LFP	72	12
20.	Tr	BiFP	42	12
21.	Tu	RF	42	10
22.	DD	LTP	40	12
23.	Tr	D	51	10
24.	Tr	RTP	35	14
25.	CVA	RFP	34	7
26.	TLE	LFP	36	10
27.	CVA	RFP	57	11
28.	Tu	LT	70	8
29.	CVA	LFP	56	8
30.	DD	RTP	46	10
31.	Tu	RTP	43	12
32.	CVA	LFP	65	12

1. CVA = Cerebral vascular disease; DD = Degenerative and demyelinating disorder; TLE = Temporal lobe epilepsy; Tr = trauma; Tu = tumor

2. L = left; R = right; F = Frontal; T = Temporal; P = Parietal; Bi = Bilateral; O = Occipital; D = Diffuse

General Considerations of Stimulus Characteristics

As mentioned earlier, in studies involving more than one sense modality the stimuli and the corresponding response curve should have a comparable guideline to reach a meaningful conclusion about the interrelationships among the different sensory dimensions. A considerable amount of knowledge about the stimulus specification in terms of precise physical energy, is available in the current literature. Expressing the stimulus input in terms of logarithmic scale is found to be useful and convenient in psychological experiments. One such scale, the decibel scale suggested by Stevens (1955, p.12), is useful for several reasons:

1. The intensity ranges of the physical stimuli are enormous-energy ranges of trillions to one are involved in vision and hearing.

2. To a rough approximation, discrimination follows a law of relativity: the just detectable increment in a stimulus is proportional to the magnitude of the stimulus (Weber's law).

   Hence, to the extent that Weber's law holds, the logarithmic difference that is just detectable is constant.

3. According to Fechner's law, the subjective magnitude of a sensation is supposed to be proportional to the logarithm of the magnitude of the stimulus.

In psychophysics there are many problems in which the ratio between the magnitude of the two stimuli is of more interest than the absolute values themselves. Here the logarithmic scale is found to be a great convenience, and fortunately a standard logarithmic scale measure expressed in a decibel (dB) unit is available today. This dB unit can be used for various sensory stimuli with an appropriate known physical reference value and thus the stimuli across modality attain comparability and precise measurement. In terms of the energy of the source of the stimulus the dB unit can be expressed as $N = 10 \log \frac{E_1}{E_0}$ where N is the number of dB, E_1 is the energy used in the stimulus source and E_0 is the reference energy.

Scaling of Stimuli

In this way a universal decibel scale has provided an excellent tool of measurement, enabling a greater comparability among cross modality data. All three sensory dimensions in the present study expressed the stimulus magnitude in dB units with appropriate reference values commonly employed by other investigators (Stevens, 1955, 1961; Bekesy and Rosenblith, 1951). Thus sound stimulus had a reference of .0002 dyne/cm^2 and the light stimulus had a reference of 10^{-10} lambert, while the vibratory stimulus had a reference of 1 dyne. Since brightness, loudness, and vibratory intensities are governed by power law (Stevens, 1955), their exponents were guidelines in setting up the experimental arrangements. These exponents are for loudness .30, and for brightness .33, i.e., the rate of change in the slope of these curves are approximately the same. The exponent of the vibratory intensity growth function is .96 (Stevens, 1959). As it was important in the present study to obtain as similar a base line (psychometric curve) as possible for all three modalities, a preliminary investigation was made to this end. Forty to 80 dB (re: 10^{-10} lambert), 40 to 80 dB (re: SL) sound intensity and 20 to 28 dB (re: SL) were found to be comparable spectrum of the three different intensity continua. These findings were similar to the results obtained by Stevens (1959). It was decided to use the sensation level (SL) as a reference in auditory and vibratory mode to determine the stimulus magnitude instead of the conventional physical reference value. The reference of SL seemed to be psychologically more potential and meaningful and some empirical findings (Hellman and Zwislocki, 1961) justify its uses. These authors found that ". . . loudness estimates as a function of SL do not differ from loudness estimates as a function of SPL [sound pressure level] . . . It eliminates the effect of the threshold on the SL of the reference standard . . . . and it reduces the inter-subject variability. . ." In the case of visual mode SL was not considered because the threshold for dark-adapted eye is less than a centibel and in the context of present experimental task SL determination was not of much consequence (minimum unit of measurement i. e., dB is many times larger than the threshold value.)

Apparatus

The auditory signal was produced by a Hewlett-Packard Audio Oscillator (Model 200 ABR). The signal was then delivered to one channel of a Garson-Stadler Electronic Switch (Model 829E) which turns the signal on and off with a specified rise-decay time. The electronic switch was activated by an Industrial Timer Inc. multi-cam timer which turned the signal on for 2 seconds. The auditory signal was then fed into a Grason-Stadler Speech Audiometer (Model 162) which amplified and provided calibrated attenuation and matched the impedence of the signal to the transducer. The auditory transducer was a TDH39, 10 ohm earphone mounted in a David Clark NSC P/N 2014 dome-type cushion with an inactive cushion on the non-test ear.

The auditory stimulus was calibrated for intensity with an Allison model 300 audiometer calibration unit. Six different intensities of a 1000 cps tone ranging from 40 dB to 80 dB sensation level (SL) were used. They were 40, 50, 55, 60 dB for the series and 80 dB for the anchor.

The vibratory signal (200 cps) was produced and controlled in exactly the same manner as the auditory signal. The only difference was that the signal was directed through the loud-speaker circuit of the Speech Audiometer (to provide greater amplification) and was transduced through a Maico bone conduction vibrator. The vibrator was kept on a spongy cushion on a table. The middle finger tip was held perpendicularly upon the diaphragm of the vibrator and in a comfortable position. While presenting the signal an earphone (same one used for presenting the auditory signal) was used to prevent any auditory cues from the vibrator. The vibratory stimulus intensity was calibrated with a Beltone 5A (SN 1007) artificial mastoid. Six different intensities at a frequency of 200 cps ranging from 20 dB to 36 dB SL were used. They were 20, 22, 24, 26, 28 dB for the series, and 36 dB for the anchor.

The visual signal was produced by a custom built high intensity flash source described by Gerbrands and Stevens (1965). The duration of the flash was controlled by an Industrial Timer Inc. multi-cam timer which was part of the complex controlling the auditory and vibratory signals. Control of the intensity of the light was provided by Kodak Neutral Density filters. The calibration instrument for the visual stimulus intensity was a Spectra Brightness Spot Meter, Photo-Research Inc. Calif. Six different brightnesses of a white light ranging from 40 dB to 80 dB (re: 10^{-10} lambert) were used. They were 40, 45, 50, 55, 60 dB for the series and 80 dB for the anchor.

The subjects were run in an IAC (Industrial Acoustic Corporation) sound treated booth. The transducers were contained inside the room, and the remainder of the apparatus was located outside of the booth. Except in the case of visual judgments, the experimenter was outside of the booth and maintained contact with the subject through the earphone and a two-way transparent glass window. In the case of visual judgment the experimenter was in the same room with the subject to change the filters in the light source manually. The room was dark and judgments were made with a dark-adapted eye. The target was 1.5 cm in diameter, and was positioned at the eye level about 30 cm away from the subject's eye.

Procedure

Each subject was asked to rate each stimulus presented. After the reading of the instructions, a practice session of two judgments on each stimulus was recorded before the actual experiment began. Thresholds were recorded for each subject for each mode (except in visual mode which were always less than 1 dB). The method of single stimuli was used for the presentation of the stimulus. Each stimulus was presented for two seconds. A warning signal (a red pilot lamp) preceded the actual signal by a second. Inter-trial interval was 10 seconds.

Since the two hemispheres, right and left were included as an independent variable (to examine the role of lateralized lesion on this kind of psychophysical task) the subjects under each sense modality were stimulated separately in both hemispheres (Cannon, 1955) in all three conditions of the experiment.

The subjects were run in three sessions (one for each modality) and each session continued for 60 to 90 minutes. The design of the experiment is presented in Table 3.

Table 3

Summary of Experimental Design

Mode	Hemisphere	Anchor	Instruction
Condition NA			
1. Auditory	Left (right ear)	No	Regular
2. Auditory	Right (left ear)	No	Regular

Table 3 -- Continued

Mode	Hemisphere	Anchor	Instruction
Condition NA (continued)			
3. Visual	Left (left nasal eye)	No	Regular
4. Visual	Right (right nasal eye)	No	Regular
5. Vibratory	Left (right mid finger)	No	Regular
6. Vibratory	Right (left mid finger)	No	Regular
Condition A			
1. Auditory	Left (right ear)	Yes	Regular
2. Auditory	Right (left ear)	Yes	Regular
3. Visual	Left (left nasal eye)	Yes	Regular
4. Visual	Right (right nasal eye)	Yes	Regular
5. Vibratory	Left (right mid finger)	Yes	Regular
6. Vibratory	Right (left mid finger)	Yes	Regular
Condition IA			
1. Auditory	Left (right ear)	Yes	Ignore anchor
2. Auditory	Right (left ear)	Yes	Ignore anchor
3. Visual	Left (left nasal eye)	Yes	Ignore anchor
4. Visual	Right (right nasal eye)	Yes	Ignore anchor
5. Vibratory	Left (right mid finger)	Yes	Ignore anchor
6. Vibratory	Right (left mid finger)	Yes	Ignore anchor

The order of testing of the three different modes was assigned on a random basis; each of the five stimuli were presented in a random order for five times in each session and the subject judged them on a nine-category scale from very very high to very very low. In Condition A the anchor stimulus was introduced along with the series stimuli for judgment, without being mentioned by the experimenter. In this session also the series stimuli were presented five times each in a random sequence but the anchor stimulus was presented in every sixth trial starting from the beginning. In Condition IA everything was the same as in Condition A except that in this condition each time the anchor stimulus was presented the subject was instructed to ignore it.

Example of instruction (in auditory mode):

> I will present a tone through the earphone and I want you to tell me how high or low it is. In front of you is a list of the measures that I want you to report to me after you have judged the tone. The tone may be very very high, or very high, or high, or medium high, or medium, or medium low, or low, or very low, or very very low. Have you any questions?

The above instruction was used for Condition NA and Condition A of the experiment. Then in Condition IA whenever the anchor stimulus was presented, this added part of the instruction was read to him:

> I want you to ignore this tone; just don't pay any attention to it.

The category scale subject used to express his judgment about the stimulus intensity consisted of the following nine points:

very very high	medium high	low
very high	medium	very low
high	medium low	very very low

To achieve quantification, integers one through nine were assigned from low to high categories and these were used as criterion measure (Guilford, 1954).

In summary, then, there were three different conditions of the experiment in each sense modality and in each group:

1. Condition NA - in this condition the subject was to judge only the series stimuli (five in number) in the prescribed manner.

2. Condition A - in this condition an anchor stimulus was introduced along with the series stimuli without being mentioned by the experimenter and the subject was asked to judge them as usual.

3. Condition IA - in this condition an instructional variable was introduced, with the anchor stimulus still in the series and each time it was presented the subject was asked to ignore the anchor stimulus in making his judgment.

CHAPTER III

RESULTS

The mean response scale values for three different groups, control non-patients (CNP), control patients (CP), combined both patient and non-patient as control group (C), and brain-damaged patients (BD) using three different modalities eye, ear, and finger under three experimental conditions, no anchor (NA), anchor (A), and ignore anchor (IA) are presented in Table 4.

Table 4

Mean response category scale values under various experimental conditions

Condition NA

Eye

	40	45	50	55	60
CNP	2.05	3.29	4.64	5.93	7.05
CP	1.90	3.09	4.42	5.67	6.86
C	1.97	3.19	4.53	5.80	6.96
BD	1.42	2.28	3.38	4.16	5.56

Ear

	40	45	50	55	60
CNP	2.34	3.62	4.82	6.04	7.28
CP	2.34	3.30	4.46	5.72	7.05
C	2.34	3.46	4.64	5.88	7.16
BD	2.33	3.14	4.24	5.35	6.72

Table 4 -- Continued

Finger

	20	22	24	26	28
CNP	2.03	3.12	4.51	5.88	7.14
CP	2.01	3.12	4.16	5.49	6.80
C	2.02	3.12	4.33	5.68	6.97
BD	2.20	3.26	4.46	5.64	6.90

Condition A

Eye

	40	45	50	55	60
CNP	1.54	2.52	3.70	4.75	6.08
CP	1.49	2.42	3.48	4.76	6.24
C	1.52	2.47	3.59	4.76	6.16
BD	1.16	1.58	2.49	3.56	4.64

Ear

	40	45	50	55	60
CNP	1.79	3.02	4.06	5.28	6.18
CP	1.82	2.70	3.62	4.78	5.96
C	1.80	2.86	3.84	5.03	6.07
BD	1.64	2.38	3.24	4.16	5.26

Finger

	20	22	24	26	28
CNP	1.58	2.50	3.54	4.76	5.78
CP	1.76	2.78	3.68	4.75	6.00
C	1.67	2.64	3.61	4.76	5.89
BD	1.55	2.23	3.36	4.45	5.34

Condition IA

Eye

	40	45	50	55	60
CNP	1.70	2.68	4.10	5.20	6.32

Table 4 -- Continued

Condition IA

Eye --(Continued)

	40	45	50	55	60
CP	1.58	2.65	4.00	5.05	6.10
C	1.64	2.66	4.05	5.12	6.21
BD	1.16	1.45	2.40	3.47	4.48

Ear

	40	45	50	55	60
CNP	2.08	3.18	4.34	5.62	6.58
CP	1.95	2.85	3.85	5.03	6.23
C	2.02	3.02	4.10	5.32	6.40
BD	1.68	2.24	3.15	4.32	5.36

Finger

	20	22	24	26	28
CNP	1.82	2.84	3.90	5.01	6.80
CP	1.84	2.86	3.84	5.04	6.23
C	1.83	2.85	3.87	5.02	6.52
BD	1.52	2.22	3.28	4.33	5.48

The mean response values in Condition NA for three different modes were compared between the control non-patient group (N = 8) and control patient group (N = 8). Since the differences between these two groups were not significant ($t = .89$ for eye, 1.40 for ear, and .10 for finger; $df = 14$ in each case; $p > .05$ in each case), these data were treated as one single control group (C) consisting of 16 subjects. Figure 1 represents the psychometric curves (fitted curve by least square

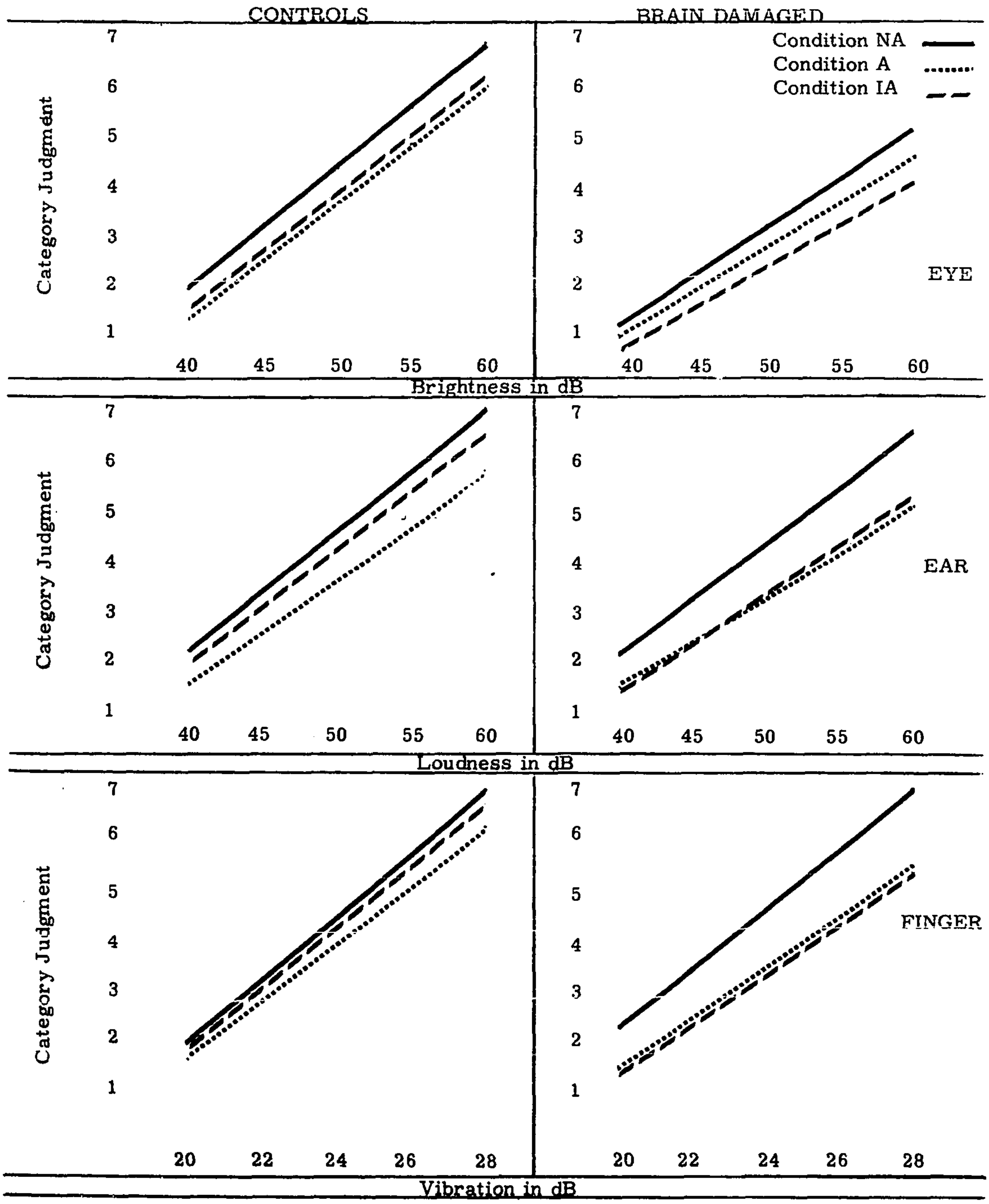

Figure 1. Psychometric curves (fitted) under various experimental conditions. Each point based on 160 judgments.

method) based on these two groups. The equations are presented in Appendix B.

Inter-Modality Correlations

It was hypothesized (Hypothesis I) that significant correlations among the anchor effects produced in the various sensory modalities in the control group would be found. To test this hypothesis difference scores for each individual between pairs of conditions, and for each modality, were calculated. Spearman rank order correlations were done among the modalities based on these different scores. Examining the correlation coefficients (Table 5) for that group would appear that partial support of the hypothesis is evidenced.

Table 5

Spearman rank-order correlations among anchor effects produced in three sensory modes

		Control			Brain-damaged		
		Eye/ Ear	Eye/ Finger	Ear/ Finger	Eye/ Ear	Eye/ Finger	Ear/ Finger
Condition NA-A	R	.62	-.05	-.34	-.05	-.55	-.01
	P	.01	NS	NS	NS	.05	NS
Condition NA-IA	R	.63	-.26	.20	.20	-.14	.01
	P	.01	NS	NS	NS	NS	NS
Condition IA-A	R	.44	.02	.05	.14	-.27	.25
	P	.05	NS	NS	NS	NS	NS

Significant correlation of intermodality judgments occurred between the visual and auditory modes among all three conditions. The non-significant eye/finger and ear/finger correlations in this same group would appear to be due in part, to the variability of the vibratory judgments.

Hypothesis II predicted a lower correlation among the anchor effects of various sensory modes in brain-damaged compared to non-brain-damaged groups. This hypothesis was supported in that all intermodal correlations in the brain damaged group were found to be non-significant with one exception: A negative correlation between eye and finger.

Instructional Set to Ignore Anchor

Hypothesis III predicted that in the control group that an instructional set to ignore the anchor stimulus reduces the effect of the apparent physical magnitude of the anchor. Figure I indicates confirmation of this hypothesis. The t-tests comparing Conditions NA and A revealed very significant differences (Table 6).

Table 6

t-tests comparing three experimental conditions in various modes for brain damaged and controls

		Eye		Ear		Finger	
		t	p	t	p	t	p
Condition NA-A	C	12.96	<.001	8.99	< .001	7.86	<.001
	BD	11.90	<.001	6.64	< .001	24.33	<.001
Condition NA-IA	C	10.00	<.001	9.75	< .001	7.25	<.001
	BD	30.4	<.001	6.76	< .001	6.39	<.001
Condition IA-A	C	3.76	<.01	5.15	< .001	4.22	<.001
	BD	3.02[a]	<.01	1.61[a]	< .20 >.10	.79[a]	<.40

[a] In this case Condition IA had lower response curve than Condition A

There were also significant shifts back toward the control condition in all modes after the instructional set (Condition IA vs Condition A). A final comparison revealed that significant differences remained between Condition NA and Condition IA. Thus, it has been shown that (1) the injection of an anchor stimulus into the series does have a demonstrable effect, and (2) the introduction of an instructional set to ignore the anchor stimulus does reduce the shift in judgment resulting from a physical anchor stimulus.

Hypothesis IV: The brain-damaged individual is not able to ignore the anchor stimulus as effectively as controls.

This hypothesis was confirmed. The brain-damaged group, while manifesting a shift in judgment similar to controls from Condition NA (no anchor) to Condition A (anchor), were <u>not</u> able to respond to the instructional set, Condition IA (ignore anchor), in the same way as the controls. As Figure 1 shows, the judgments of the brain-damaged group in Condition IA were even lower than in Condition A, a finding which is in marked contrast to the behavior of the control group. Indeed, in one modality, the visual, Condition IA was found to be significantly lower than Condition A (Table 6).

Magnitude of Anchor Effect

Hypothesis V stated that the anchor effect is significantly greater in the brain-damaged group than in the non-brain-damaged group. There are two ways in which this hypothesis was tested. In the first a simple subtraction procedure was employed (Condition NA-A). In the second a procedure developed by Helson (1964) was used to indicate the relative effect of background and focal stimuli on the judgments.

In the first procedure (Condition NA-A) used to test the hypothesis, confirmation was found only in the vibratory touch mode. The mean difference measures reflecting the amount of shift in the psychophysical scale and the tests for significance of these shifts are presented in Table 7.

Table 7

Mean anchor effects (Condition NA-A) in three modalities for control and brain-damaged group and t's between the groups

	Eye	Ear	Finger
C	.82	.77	.64
BD	.69	.91	1.18
t	1.98	1.21	8.3
p	.10	.20	.001

In the second analysis Helson's approach (Appendix C) was utilized. In this approach the relative contributions of focal (series stimuli) and background (anchor stimulus) factors to the psychophysical judgments were obtained. The mean differential weights for focal and background stimuli and their ratio for the two groups are presented in Table 8. Using a difference score between the focal and background a group x sense mode x condition (2x3x2) analysis of variance revealed significantly greater effects in the brain-damaged group in all three sensory modes ($F=299.40$; df 1, 2; $p < .001$) i.e., the anchor condition affected the brain-damaged group to a greater degree. In Helson's system this finding indicates that the brain-damaged group is more influenced by background stimulus (anchor).

Table 8

Mean differential weights of background (B) and focal (F) stimuli involved in the judgment processes in Condition A and Condition IA

	Condition A			Condition IA		
Control						
	B	F	B/F	B	F	B/F
Eye	.199	.801	1/4	.168	.832	1/5
Ear	.205	.795	1/4	.135	.865	1/6
Finger	.195	.805	1/4	.133	.867	1/6
Brain-damaged						
	Condition A			Condition IA		
	B	F	B/F	B	F	B/F
Eye	.417	.583	1/1	.506	.494	1/1
Ear	.308	.692	1/2	.279	.721	1/3
Finger	.274	.726	1/3	.278	.722	1/3

Anchor Effects and Hemisphere Dysfunction

Hypothesis VI, "There are differential anchor effects between the right and left hemisphere stimulations in the brain-damaged subject when the lesion is lateralized," was not confirmed. Analysis by Sign test (Siegel, 1956) for non-independent measures was performed first by grouping the patients with left hemisphere lesions (N = 7) and comparing their left hemisphere performance with their right hemisphere performance. The same was done with the patients with right side lesions (N = 6). The final analysis was performed by grouping all the subjects in terms of "good" vs. "bad" side. It can be seen in Table 9 that none of the comparisons were found to be significantly different.

Table 9

Mean anchor effects (Condition NA-A) in three modalities in terms right and left hemisphere lesion and sign test between the two hemispheres

		L	R	N	X	p
Left Hemisphere Cases	Eye	.74	.44	7	3	.23
	Ear	.96	1.00	7	4	.50
	Finger	1.42	1.40	7	3	.50
Right Hemisphere Cases	Eye	.91	.76	6	3	.66
	Ear	.78	.66	6	3	.66
	Finger	.82	.80	6	3	.66
		Good side	Bad side	N	X	p
All Cases	Eye	.67	.72	13	5	.13
	Ear	.89	.81	13	7	.50
	Finger	1.11	1.11	13	6	.55

CHAPTER IV

DISCUSSION

The hypotheses advanced in this experiment led to predictions of (a) a role of central mediating processes in heteromodal psychophysical judgment, as evidenced through anchor effects in sensory modes under different instructional "set" conditions and; (b) differential anchor and "set" effects in patients with CNS dysfunction. In general, the hypotheses were confirmed. Since the main focus of the study was upon the anchor effect due to various organismic (set and CNS) and stimulus variables, the Hypotheses (III, IV and V) related to the anchor effects will be discussed first. Next, results pertinent to the issue of central participation (Hypotheses I and II) in the multi-modal psychophysical behavior will be explored. And finally the implications of these findings for Helson's AL theory and the "set" theories of Hebb and Goldstein.

Anchor Effects

The experimental paradigm used in the preceding experiment was designed after Helson (1947, 1948, 1964). The paradigm involved procedures whereby the subject made initial judgments on a series of lights, sounds and vibrations (Condition NA). An extreme value (anchor) to this series was introduced without the experimenter mentioning it (Condition A). The effect of the anchor stimulus was a very significant one and confirms previously reported findings by a number of experimenters (Brown, 1953; Michels and Helson, 1954; Parducci and Marshall, 1962). Of greater interest is the fact that the brain damaged sample also behaved in a quite similar manner. The consistency of response across the various sense modalities in both groups not only confirms the previous results but also extends these findings across the different population and a different sense modality (Vibratory).

Ignore Anchor Set

Perhaps the most significant finding in the present experiment was the large differential group performance under the set to ignore the anchor (Hypotheses III and IV). The effect of this condition in the control group was to reduce the anchor effects, as hypothesized. As seen in Figure 1 the curve shifts back toward the no anchor condition; the levels of significance of the shift back toward the initial reference curve are all beyond the .01 level of confidence. Brown's findings (1953) were similar for weight lifting judgment in 'Don't judge the anchor' condition of the experiment. This can be seen as evidence for the effect of a cognitive mediating process in the determination of a simple sensory judgment. Again in the control group it occurred with consistency across all three sense modalities.

However, the brain damaged group did not change their judgments as a result of the instructional set. Their responses in Condition IA were near or below their level for Condition A. In effect, the brain injured group were unable to respond to the instructional set in the same way as the control group. Several explanations for this behavior seem possible. It could be argued that the brain damaged Ss did not pay attention to the task or instructions. This is not likely for two reasons. First, during the process of selecting the patients it was made sure that they were capable of understanding the instructions and could go through the experiment. Second, the data do not support this notion. In the NA condition the brain damaged group acted very similarly to the control group (Fig. 1). In fact distributions of category judgments over the scale in all modalities (Appendix G) were not significantly different for the brain-damaged and controls as tested by the Kolmogorv-Smirnoff test (Seigel, 1956). Immediate memory loss, as an explanation for the IA effect does not seem tenable because the instructions were repeated each time, immediately before the anchor was presented in that condition.

One way of interpreting the results of the instructions on sets is from the "within subject" analysis of the experiment. Condition NA could be considered the control condition and Conditions A and IA the experimental conditions. Further, Condition A may be considered the "concrete" experimental condition, i.e., an extreme physical stimulus (anchor) entered the phenomenal field, and Condition IA the "abstract" condition, i.e. where the subject is to respond in a conceptual manner in accord with the instructions to ignore this same extreme physical stimulus. Looking at the experiment in this way the failure of the brain-damaged group in the "abstract" condition is readily apparent.

The above interpretation is consistent with Goldstein's (1963) theory. In his extensive work with brain injured soldiers he found an impairment which he conceptualized as an impairment of the ability to assume the abstract attitude; the inability to remove oneself from the very immediate phenomenal experience. Goldstein (1942) summarizes this notion:

> We are given over and bound to the immediate experience of a given thing or situation in its uniqu-ness. Our thinking and acting are directed by the immediate claims that one particular aspect of the object or situation in the environment makes. The nature of these claims may be experienced in different forms: as an expressive quality of the physiognomy of things, as situational "belongings" or familiarity. We respond unreflectingly to these claims. (p. 89)

The abstract attitude, on the other hand, allows one to transcend this immediate phenomenal world and respond to higher levels of conceptual activity. In the present experiment the instructional set to ignore the anchor, even though it was experienced in the physical and phenomenal sense, could be an example of this higher conceptual activity. The degree to which the subject could respond to the instructional set could be termed a measure of his ability to transcend the immediate experience of the series involving an extra anchor stimulus. As the results indicate, the brain injured subjects were markedly less able to respond in this manner.

This demonstration of concrete thinking is unique in the sense that it involves no reference to the subject's language behavior other than a simple indication of one of the nine categories. Much of Goldstein's work and demonstrations of the concrete attitude were concerned with concreteness as it appeared in language communications. One of the criticisms of language instances of concrete thinking centers around the effect of learning. The argument states that it is not known if the subject has learned the concept previously; and, this being the case, he is unable to use the concept illustrative of the abstract attitude. In the present study the task is simple, the instructions are plainly within the learning ability of all subjects, and therefore, the effects of learning and language sophistication are felt to be minimal.

Differential Anchor Effects

Hypothesis V predicted that a differential effect of Condition A would also be observed between the brain-damaged and control groups. In terms of previous discussion it might be said that the brain-injured subject would react more to "concrete" conditions. In the initial analysis of the anchor shifts Hypothesis V was not confirmed except in the tactual modality. However, the effects shown in Table 6 are a result of subtraction between Conditions NA and A and do not utilize the data in the most efficient way. A subsequent analysis using Helson's (1964) approach clearly indicated that the introduction of the anchor had a greater effect on the brain-damaged group. This analysis is a measure of the relative contribution of focal (the stimulus series) and background (anchor) factors in the adaptation level paradigm. In the brain-damaged group approximately equal emphasis was placed on these two factors, focal and anchor stimuli.

In the control group, on the other hand, emphasis on the focal stimuli was four times that of the emphasis on the background factors. In this same analysis it was shown that in Condition IA (ignore anchor instructions) the control group placed five times the emphasis on the focal (series) as opposed to the background stimuli. This difference in emphasis on focal and background stimuli between Condition A and Condition IA reflects the ability of the controls to shift their set as a result of the instructions. In the brain-damaged group the relative contribution of focal and background factors remained the same. In the visual modality there was actually a tendency to shift even further in the concrete direction, i.e., an even greater effect of the anchor was seen in spite of the instructional set to ignore it!

Indeed, considering Condition IA-A (in Table 4) in all modes the BD group were more influenced by the background (anchor) when they were asked to ignore it. One explanation for such an effect would be that the brain-damaged group are not only unable to function at an 'abstract' level (cognitive mediation) but also highly stimulus-bound. In the Condition A an anchor stimulus was introduced without any mention of it to the subject while in Condition IA, subject's attention was focussed to the anchor stimuli and then paradoxically they were asked to ignore it. This kind of incongruency was fairly well handled by the control subjects, but the brain-damaged group responded, under these conditions, in an additive manner: (1) they reacted to the anchor stimulus similar to the controls in Condition A but, in addition, (2) reacted to the 'concrete' aspect of the instruction, i.e., there is a stimulus. This 'attention' resulted in heightened saliency of the anchor stimulus, a stimulus-bound concreteness.

Inter-Modality Correlations

Given these very significant anchor, instruction set, and group effects the question of the correlations (Hypotheses I and II) among the sense modalities now may be considered. Significant correlations, as predicted, occurred between anchor effects in the sight and auditory mode for the control group but none of the correlations involving vibratory sense were significant. Also, as predicted, the correlations were lower (non-significant) in the brain-damaged. The latter is understandable; if, as postulated earlier, there is some central mediating or regulatory mechanism involved in the reception as well as the integration and output of sensory information, then it is not surprising that it may be affected by brain injury.

The lack of correlations of eye/finger and ear/finger in the control group, however, necessitates detailed consideration. Noting that the vibratory sense mode is the one that is contributing to the failure of these two comparisons, it is appropriate that this modality be scrutinized more closely. A first consideration might be a general evaluation of the physiological nature of this modality as compared to the visual and auditory modalities. For instance, it would hardly be contested (Granit, 1955; Geldard, 1940) that the tactual modality which is intimately involved in the vibratory sense is the least sophisticated in terms of physiological structure. When one considers the concept of specialization of structure it can readily be noticed that the cell receptors in the eye and ear are much more specialized. And besides being more specialized, it can also be noted that the distribution or density of receptor endings is much larger in the retinal and basilar membrane surface.

Another possible consideration that may contribute to this notion of a less specialized sense is the fact that there is always a confounding when the vibratory and tactual senses are considered. Pressure, heat, cold and pain reception also are situated in the same areas and their very consideration as separate senses is questioned by some. As Granit (1955) states,

> I, for one, feel that there is no difference between the modalities of 'touch' and 'pressure' other than one of quantity (strength). They are not so distinctly different experiences as the two qualities 'red' and 'green'. (p.39)

Granit also discusses the difficulty of assessing this modality due to the fact that organs of reception are so hidden in the skin. He further states that sensations as well as impulses in response to touch and pressure arise from skin deformations with unknown distribution of the forces around the organs.

And finally, one may make an argument concerning the differential emphasis sociocultural and evolutionary processes place on the visual and auditory modes compared to touch. Indeed, given the human situation there is less survival value attached to the touch modality than the "distance" receptors. Relatively fewer demands are made on the tactual sense as an avenue of information helping the organism to adjust to the environment. Evidence for this interpretation has been noted in the study of tactual sensation in blind subjects (Scott, 1966)*

Central Factors

The primary evidence for the central aspects of the heteromodal judgments used in the present experiment then, is twofold: the lack of correlations in the brain-damaged and the very significant relationship between judgments in the visual and auditory modalities.

The latter findings, in agreement with Behar and Bevan (1961), are interpreted as reflecting central aspects of the complex judgmental processes. In the past, sensory data were often thought to reflect only peripheral mechanisms to be studied in isolation. But, with the development of the concept of central control of receptor activity (Granit, 1955) as well as concepts of "feedback" and "reverberating circuits" the

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* Personal Communication from R.W. Scott, University of Houston, Houston, Texas.

integrative aspects of sensory functioning have come into focus The inclusion, however, of the tactual modality in the analysis did not add to the generality of the inter-modal similarities. The explanation of this particular finding was handled previously in terms of a decreased specialization of cells.

A final bit of evidence concerning this central mediation of receptor events can be observed in the lack of differences resulting from lateralization of lesions (Table 9). In this case there was no variance in the results that could be attributed to the lateralized site of the lesion. This finding was not consistent with the original hypothesis, but supports the notion of control mediating processes.

In summary, there appears to be considerable support for a notion concerning the central mediation between the sense modalities of vision and audition. The failure of the vibratory mode to contribute to this finding, at least in the manner and degree expected, may, in part,be due to lack of technique to test its contribution rather than its having no effect. The differences in receptor specialization would appear to dictate the development of new research strategies for a more adequate test of the "central factor" hypothesis.

Implication for Theory: AL

The experimental procedures used in the present were framed after Helson's psychophysical judgment experiments. It has provided a unique and well-standardized system from which to obtain answers to the questions posed. But, as is often the case in experimental work, the results give more information than can be predicted with the initial theory. This is a function of the predictive limitations of theories which are projected to groups differing from those on which the original theory was based. The results of Ss with central nervous system pathology is a case in point. The predictions made for them were based on knowledge of brain injured patients and their behavior; not from within the logic of Adaptation Level Theory. This situation has two important implications: (1) it adds to the generality of the theory, (2) but in so doing places an obligation on the experimenter to interpret his findings within the initial theory.

The explanation of differential performance of the brain-damaged in the IA Condition within Helson's theory centers on his conception of the factors that influence human behavior, i.e., focal, background and residual. Within this schema the majority of experimental manipulations are concerned with the focal and background factors; the residual factors being by definition largely unavailable. This being the case these residual variables are frequently assumed to be constant through random sampling and controls for age and education. This leaves consideration of the present findings in the light of focal and background factors. As was mentioned earlier it was shown that the brain-damaged were not as responsive as controls in the focal stimulus condition. Now since the sum of these two factors are equal to unity one it follows that this lesser emphasis on focal factors reflect a greater emphasis on background factors. This, of course, was seen in the Condition A (Table 8). The brain-damaged subjects placed a significantly greater emphasis on these background factors; so much so that they could not subsequently successfully ignore these same stimuli. It is necessary to depart from Helson's framework in the attempt to explain why the brain-damaged group were unable to shift their set and respond in the direction of attenuating the effect of the anchor in the judgments. Here one must begin to talk of subject variables either in terms of psychological sets, dispositions or simply rigidity of psychological functioning. These theoretical questions concern the states of the organism that are related to brain injury.

Set

As Gibson (1941) points out the use of the concept of set must be accompanied by some definition. Without this one can become quickly lost in the maze of meanings and connotations that reach far back in psychological literature. So in order to avoid confusion, the approach of Gottlieb (1959) will be followed where "set" will be used "in a relatively atheoretical sense, to refer to a general class of inferred subject variables which have been found to operate between afferent stimulation and various response indicators. . ." Gottlieb (1959) made inferences concerning the change of set from changes in performance resulting from variation in instructions. This work established that changes in instructional set do result in differential performance of brain damage and control patients.

In the present experiment this differential effect of instructional set was again demonstrated. The "ignore anchor" condition resulted in very significant differences; the brain-damaged individual being unable to respond to the verbal instructions requiring a cognitive mediation between the stimulus situation and adequate performance. Of course, the theoretical crux of the situation is in the interpretation of these "set" differences.

As Hebb (1949) suggests, discussion of a concept of set implies, among other things, reference "to the hypothetical agency or process which produces the selectivity" of responses. In the present study these hypothetical processes are felt to be concerned with central neural facilitation of perceptual activity. (Hebb, 1949). The manipulation of these processes are reflected in group (BD and control) differences and at the descriptive level are referred to as cognitive deficit. So, interpretively, these findings add evidence to this particular view of psychological set and its relationship to organismic or subject variables. Whether set is called "attention", "disposition", is not as important as seeing it in terms of the organism adapting to its environment to a greater or lesser degree of efficiency. And this notion of the organism adapting to the environment is also similar to Goldstein's (1963) discussion of the brain injured patient coming to grips with the demands of the task.

Goldstein's (1963) approach to the cognitive behavior of brain injured subjects, as suggested earlier, is concerned with two broad levels of such behavior; the concrete and the abstract. This schema for cognitive behavior states that a predominant characteristic of normal functioning is demonstrated by the ability to shift from the concrete to the abstract level as the situation and context would dictate. In Helson's (1964) system the background stimulus context would dictate this shift of cognitive level. Goldstein (1941) gives an example of this lack of shifting ability.

> "A patient who has just succeeded in reciting the days of the week is now asked to recite the alphabet. He cannot shift to this task, and only after repeated promptings, or better stated, after the examiner has commenced to call out the alphabet, can the patient follow in his recitation." (p. 5)

In the present experiment the failure of the brain injured patients to "shift" in accordance with the instructional set illustrates the deficit about which Goldstein speaks. It would have been interesting in this study to provide the "repeated promptings" and see how resistant this rigid behavior is to modification. More modern interpretations of Goldstein's system does not stress the complete unavailability of abstract functioning on the part of brain injured subjects. In fact the very dichotomy of abstract-concrete is now viewed in more relative terms; more as a continuum of psychological functioning. It is within this context that attempts to define the conditions which facilitate adequate abstract functioning in brain injured patients are framed. In this study the attempt to define the stimulus and response aspects (a la Helson, 1964) of the task in a systematic and quantitative way is a step toward the definition of these conditions.

CHAPTER V

SUMMARY AND CONCLUSIONS

Modern students of perception have come to realize the inadequacy of the traditional static relationship between stimulus and response. Perception is currently viewed as a complex outcome of behavior involving both internal (organismic) and external (stimulus field) variables. The perceiver is seen as an active contributor to the perceptual process. Even in the field of psychophysical judgment the role of organismic variables has received new emphasis.

However, the role of conceptual processes in psychophysical judgment has not been extensively investigated. This is especially true when more than one sensory modality is considered.

The Adaptation level (AL) theory of Helson (1964) recognizes the complexity noted above and considers that perception is an adaptive process which is highly dependent upon the previous experience of the organism as well as the focal and background stimulus conditions. It offers a mathematical model allowing prediction and empirical verification of perceptual behavior. Adaptation level is the weighted mean of all the stimuli affecting behavior temporally or spatially. This principle recognizes that besides the stimulus manifold, the internal organismic factors affect the perceptual dimension in keeping with the states of needs, values, and feelings of the individuals. Perceptual-judgmental behavior is a result of interactive forces of both internal and external factors. Much of Helson's research has been concerned with anchor effects, i.e., the introduction of a stimulus outside of the series stimuli which affects the psychophysical judgments.

There are many interesting questions which arise in connection with Helson's AL approach to psychophysical judgment: Is there a central mechanism which after the reception of the sensory input, decodes the signal and interprets it in a consistent manner? Is it possible that there is a generalized and consistent scaling behavior expressed in psychophysical judgments which transcends various sensory modes? Could there be a consistency of anchor-effect across the modalities leading to a general adaptation level concept on a central-integrative basis? Can anchor effects be varied by instructions to "ignore the anchor"?

Helson has not adopted a position on heteromodal consistency but a review of the literature (Behar and Bevan, 1961; Brown, 1953) suggests that there is indirect evidence for such central components affecting psychophysical judgments or, more specifically, the response to the anchor stimulus in several modalities. However, correlations among anchor effects in different sensory modes have not been directly demonstrated. This latter aim, together with examination of the influence of an instruction-induced set to "ignore the anchor" upon the anchor effects, were the concern of the first part of this study.

A second aspect of the investigation was the variation in physiological state of the organism (CNS intact vs. impaired) and its impact on psychophysical judgments. If central processes play an important role in psychophysical judgment then brain injury may well lead to different answers to the above questions than would be found in the control group. There is much evidence to suggest that CNS dysfunction would lead to lower correlations among the anchor-effects in different sense modalities in the brain-damaged group. Further, since brain-damaged individuals have, as described by Goldstein, difficulty in distinguishing figure and ground and shifting sets, it was expected that the anchor (background) stimulus effect would be greater in this group and that they would be less able to "ignore" the anchor than the controls.

On the basis of the above the following hypotheses were made.

Hypothesis I: There will be significant correlations among the anchor effects produced in the various sensory modalities.

Hypothesis II: There is a lower correlation among the anchor effects of various sensory modes in brain-damaged group compared to non-brain-damaged group.

Hypothesis III: An instruction induced set to ignore the anchor stimulus reduces the effect of the apparent physical magnitude of the anchor.

Hypothesis IV: The brain-damaged individual is not able to ignore the anchor stimulus (as required by instruction) as effectively as the controls.

Hypothesis V: The anchor effect is significantly greater in the brain-damaged group than in the non-brain-damaged groups.

Hypothesis VI: There are differential anchor effects between the right and left hemisphere stimulations in the brain-damaged subjects when the lesion is lateralized.

To test these hypotheses an experiment was designed which included (1) two groups differing in physiological state; 16 brain injured, 8 patient control and 8 non-patient control matched on age and education; (2) three sensory modes of presentation: visual, auditory and vibratory touch, and (3) three experimental conditions: no anchor (NA), anchor (A) and ignore anchor (IA). The initial condition was the standard judgment condition of a stimulus series (9 judgment categories of 5 stimulus intensities). The anchor condition involved the inclusion of a 6th stimulus value which is above the largest series stimulus. The subject was not told about the inclusion. The last condition, involved instructing the subject to ignore the anchor stimulus and judge the rest of the stimulus series. The design required each subject to make 150 separate judgments in each of the three sensory modalities.

In order to make a valid conclusion about the nature of interrelationship among various sensory modalities the initial part of the experiment was designed to obtain a base line of psychometric curve. A common logarithmic scale in dB unit was utilized to describe all three stimulus qualities with appropriate reference values. Forty to 80 dB in brightness and loudness intensities and 20 to 36 dB in vibratory intensity produced a comparable psychometric curve in this experiment.

The results generally supported all hypotheses, except Hypothesis VI. Specifically:

1. Introduction of the anchor stimulus produced a significant effect on the psychophysical judgment in both control and brain-damaged subjects.

2. Using Helson's approach for analyzing the data, the relative contribution of the anchor (background) stimuli to the judgments was significantly higher (as predicted) in the brain-damaged group than the controls in all three modalities.

3. Instructional set to ignore the anchor was found to have a definite role in the outcome of the psychophysical behavior. In the case of the control group the influence of the anchor stimuli was reduced to a significant extent in all modes.

4. The brain-damaged group on the other hand, in accord with the prediction, did not shift in response to the instructional set. In fact, in the visual mode their responses in Condition IA were significantly lower than in Condition A; similar trends were found in the other sensory modes.

5. Testing the hypothesis of a central mediating mechanism at the cortical level behind the reception, integration, and output of sensory

information, correlations among the anchor effects in all three modes were examined. All the correlations involving eye and ear were significant in the control group but the correlations involving finger were not significant.

6. Correlations among the anchor effects in the eye and ear modalities were significantly lower in the brain-damaged group than the controls.

7. The prediction of differential anchor effect as a result of hemisphere involvement was not significant.

The first major finding in this study, the prediction of a significant shift of AL as a result of the introduction of an anchor stimulus was confirmed at a high level of confidence. This finding is noteworthy in that similar results were obtained with brain-damaged patients; a group that has not been previously studied using AL theory.

Support for the operation of central processes in psychophysical judgment was found in the significant correlation between the visual and auditory modes of the control group, but none of the correlations involving the vibratory sense were significant. The failure to find correlations involving the vibratory modality was discussed in terms of a lack of specialization of receptor activity. All intercorrelations in the brain-damaged group were lower than controls, as hypothesized.

Perhaps the most interesting finding in the present investigation is related to the very significant differential effects between groups in response to the "ignore anchor" experimental condition. The control group as hypothesized, manifested a reduction in anchor effects. The brain-injured group, however, had no reduction of anchor effect in response to the instructional set; in fact, the anchor effect was enhanced. This failure is interpreted as a reflection of a deficit in higher cognitive functions; a finding not uncommon with brain injured groups. Theoretical considerations of this finding were discussed in terms of AL theory, set and within the Goldstein's framework. Probably the most meaningful interpretation was found in Goldstein's approach with constructs of "concrete" and "abstract" thinking as well as "lack of shifting." In Goldstein's terms the failure of the brain-injured group to respond to the cognitive instructional set was a reflection of both concrete thinking and a lack of shifting. They were unable to transcend the effect of the physical anchor and shift their set in response to the ignore anchor instruction. This finding was also pointed out as significant in that performance was independent of the influence of learned skills, especially verbal skills.

The prediction of a differential effect for groups in the shifts to the anchor stimulus was confirmed when the data were analyzed within Helson's (1964) AL theory. The analysis provided a measure of the relative contribution of focal (the stimulus series) and background (anchor) factors in the AL paradigm. In the brain damaged group approximately equal emphasis was placed on these two factors in both

A and IA Conditions. In the control group, however, emphasis on the focal stimuli was four times and five times the emphasis on background factors in the A and IA Conditions. These differences were highly significant.

The main implication of this study is that there is strong evidence for a common sub-stratum subserving various psychophysical behavior, a central mediating mechanism integrating the inputs from various receptor systems. Injury to the cortical neural tissue apparently impairs and interrupts the integrating mechanism as evidenced by the lack of correlation among psychophysical judgments in the various senses for the brain-injured. However, within the brain-injured group when "good" vs. "bad" (impaired) hemispheres were compared, no differential effects were found. These findings emphasize that the deficit does not lie at the specific cortical projection area level, but rather at the more central molar brain process level. This formulation is in line with Hebb's constructs of cell assemblies or phase circuits, referring to functional neural systems which provide a common basis for perceptual-cognitive behavior.

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APPENDIX A

MEAN RESPONSES (5 TRIALS) FOR 5 DIFFERENT INTENSITIES IN 3 DIFFERENT MODES UNDER 3 DIFFERENT EXPERIMENTAL CONDITIONS

Condition NA: Control

							Eye						
S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
1	L	22	30	36	52	58	9	L	26	42	52	62	74
	R	24	30	42	50	60		R	28	36	54	60	72
2	L	22	36	50	64	80	10	L	22	30	44	60	74
	R	22	36	48	66	76		R	20	28	42	58	72
3	L	22	36	54	62	72	11	L	14	28	50	56	68
	R	22	32	44	64	74		R	14	32	44	56	62
4	L	24	40	54	62	76	12	L	18	28	40	54	70
	R	18	26	40	50	68		R	16	26	40	50	64
5	L	20	32	48	62	72	13	L	18	34	40	48	60
	R	20	48	56	64	74		R	16	32	42	58	64
6	L	20	30	52	62	72	14	L	18	28	44	56	70
	R	24	36	46	60	72		R	14	28	40	60	74
7	L	18	32	52	62	70	15	L	22	32	44	56	70
	R	16	26	40	52	66		R	18	30	42	58	66
8	L	18	28	44	60	72	16	L	20	30	46	60	72
	R	16	28	40	56	66		R	20	30	44	54	68

Condition NA: Control

						Ear							
S#	Hemis. dB:	40	45	50	55	60	S#	Hemis. dB:	40	45	50	55	60
1	L	24	28	40	50	64	9	L	32	40	52	62	74
	R	16	26	44	56	64		R	30	40	50	62	76
2	L	20	36	50	62	78	10	L	24	30	40	54	68
	R	18	32	52	60	74		R	24	38	48	60	72
3	L	20	38	52	62	74	11	L	20	34	54	56	70
	R	24	36	48	62	76		R	20	34	44	54	72
4	L	26	42	52	60	72	12	L	20	32	46	58	70
	R	22	36	46	58	76		R	24	36	48	60	74
5	L	22	34	46	58	74	13	L	28	34	46	60	70
	R	18	32	48	64	78		R	24	32	40	58	74
6	L	26	40	54	68	80	14	L	20	24	30	48	64
	R	36	48	50	64	78		R	22	30	40	56	68
7	L	26	40	48	60	68	15	L	22	30	38	50	64
	R	28	36	46	64	70		R	20	30	44	60	68
8	L	26	38	46	56	72	16	L	22	32	48	62	74
	R	26	36	46	62	68		R	22	32	46	56	70

Condition NA: Control

						Finger							
S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
1	L	22	30	52	60	76	9	L	22	32	42	54	68
	R	20	26	46	64	76		R	20	34	50	62	74
2	L	16	30	44	54	70	10	L	20	30	44	62	80
	R	14	24	42	54	70		R	18	32	44	62	78
3	L	22	30	46	58	76	11	L	14	22	32	40	54
	R	24	32	52	64	74		R	18	26	30	42	56
4	L	26	38	50	64	74	12	L	26	36	48	62	74
	R	22	44	56	64	76		R	30	38	50	62	78
5	L	18	30	44	64	76	13	L	18	24	32	58	76
	R	18	34	48	66	78		R	20	32	48	60	74
6	L	22	28	38	52	66	14	L	18	34	48	52	60
	R	24	34	44	54	70		R	22	34	42	50	62
7	L	14	32	40	58	68	15	L	16	34	42	56	68
	R	20	30	44	64	72		R	28	38	44	64	72
8	L	18	32	38	50	60	16	L	18	26	38	48	56
	R	24	34	40	52	62		R	14	26	32	44	58

Condition A: Control

Eye

S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
1	L	18	24	30	44	50	9	L	16	28	40	52	62
	R	13	30	32	44	50		R	16	34	48	58	62
2	L	16	28	46	54	66	10	L	18	22	36	50	62
	R	16	26	42	52	64		R	18	20	34	50	60
3	L	16	32	50	54	64	11	L	10	18	20	30	38
	R	20	30	38	54	66		R	10	20	28	36	52
4	L	18	28	48	58	64	12	L	18	28	40	50	62
	R	14	24	30	40	58		R	14	24	36	48	60
5	L	16	26	44	54	62	13	L	14	26	32	48	56
	R	16	28	40	48	62		R	14	20	28	50	60
6	L	18	22	39	52	64	14	L	16	22	36	50	64
	R	14	24	34	44	56		R	14	24	36	54	60
7	L	12	22	30	46	58	15	L	16	22	34	40	62
	R	10	20	28	40	56		R	16	32	40	54	60
8	L	14	20	30	36	56	16	L	14	22	36	44	58
	R	12	20	32	46	56		R	14	26	34	48	60

Condition A: Control

S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
						Ear							
1	L	18	24	30	44	54	9	L	20	36	44	50	60
	R	14	20	30	42	52		R	22	34	40	52	64
2	L	16	32	44	54	70	10	L	22	30	38	46	58
	R	14	28	40	54	62		R	16	24	36	46	60
3	L	18	36	44	58	64	11	L	14	22	30	46	50
	R	20	34	44	62	68		R	14	20	28	34	48
4	L	20	40	46	58	64	12	L	20	28	40	50	64
	R	16	32	42	56	68		R	20	28	38	52	64
5	L	20	32	44	60	68	13	L	18	28	34	48	64
	R	16	32	42	56	68		R	20	26	38	52	64
6	L	20	30	44	54	68	14	L	18	22	30	46	56
	R	22	30	42	56	64		R	20	28	38	50	62
7	L	16	34	44	50	56	15	L	18	28	36	48	58
	R	22	32	44	50	62		R	16	28	34	48	60
8	L	14	24	32	42	52	16	L	16	24	38	46	60
	R	18	26	38	46	50		R	18	26	38	50	62

Condition A: Control

Finger

S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
1	L	16	26	42	50	60	9	L	20	32	36	48	58
	R	14	28	40	48	56		R	18	28	44	56	66
2	L	18	22	34	50	54	10	L	16	28	38	50	64
	R	12	20	34	52	64		R	16	26	40	52	64
3	L	18	22	30	44	60	11	L	12	22	26	34	48
	R	18	22	28	42	56		R	18	24	26	36	48
4	L	24	34	40	56	64	12	L	24	36	44	58	68
	R	16	40	46	48	60		R	24	36	48	58	70
5	L	20	32	44	50	62	13	L	16	26	36	48	60
	R	16	28	32	58	66		R	18	28	38	52	64
6	L	16	20	32	42	58	14	L	16	28	38	46	56
	R	14	36	42	48	52		R	18	24	34	46	58
7	L	12	18	30	44	56	15	L	16	36	44	50	62
	R	14	20	28	44	54		R	20	30	36	48	64
8	L	18	24	30	42	52	16	L	16	16	24	38	50
	R	16	24	34	44	52		R	14	24	36	40	56

Condition IA: Control

							Eye							
S#	Hemis.	dB: 40	45	50	55	60		S#	Hemis.	dB: 40	45	50	55	60
1	L	20	26	32	46	50		9	L	18	36	44	58	68
	R	18	26	34	50	52			R	16	30	48	60	64
2	L	16	30	48	58	68		10	L	16	24	38	52	66
	R	16	30	46	50	66			R	18	20	40	54	66
3,	L	18	32	52	56	68		11	L	10	20	30	32	42
	R	20	30	40	56	70			R	14	30	40	48	56
4	L	20	26	50	62	70		12	L	20	28	42	52	62
	R	14	24	34	46	62			R	14	24	38	48	64
5	L	16	28	44	60	66		13	L	14	32	38	48	58
	R	20	36	48	60	68			R	14	24	40	54	62
6	L	18	24	42	56	64		14	L	18	20	40	48	66
	R	16	26	38	46	62			R	14	20	40	54	64
7	L	16	24	40	46	60		15	L	16	24	40	48	64
	R	14	24	38	52	62			R	16	30	42	56	60
8	L	16	22	36	46	64		16	L	16	26	36	48	58
	R	14	22	34	52	60			R	18	26	42	52	64

Condition IA: Control

S#	Hemis.	dB: 40	45	50	55	60	Ear	S#	Hemis.	dB: 40	45	50	55	60
1	L	18	26	34	50	52		9	L	22	38	50	50	56
	R	16	22	34	46	58			R	24	36	44	60	70
2	L	18	26	46	58	70		10	L	22	32	40	48	62
	R	18	26	40	56	66			R	18	24	38	48	64
3	L	20	38	48	60	68		11	L	16	24	32	50	56
	R	20	34	46	64	72			R	14	16	30	34	56
4	L	20	42	48	64	66		12	L	20	28	42	52	64
	R	18	34	44	58	72			R	24	32	42	56	68
5	L	22	30	46	62	70		13	L	20	28	40	52	66
	R	20	32	44	62	66			R	20	34	38	52	68
6	L	22	34	48	58	74		14	L	18	22	32	46	58
	R	22	30	46	58	70			R	20	26	38	54	62
7	L	18	32	50	54	66		15	L	18	28	36	50	60
	R	26	34	44	50	64			R	18	30	36	50	60
8	L	14	22	32	50	62		16	L	18	28	40	50	64
	R	22	30	44	50	58			R	20	30	38	54	62

Condition IA: Control

Finger

S#	Hemis.	dB: 20	22	24	26	28	S#	Hemis.	dB: 20	22	24	26	28
1.	L	18	28	46	56	68	9	L	20	32	38	50	62
	R	18	26	42	58	64		R	20	30	48	62	68
2	L	18	28	34	52	58	10	L	16	30	42	56	68
	R	16	24	38	54	70		R	18	26	42	54	66
3	L	18	24	32	48	66	11	L	12	20	26	38	50
	R	20	26	36	48	64		R	16	24	26	38	48
4	L	26	36	44	62	68	12	L	24	38	44	60	72
	R	18	44	48	52	66		R	26	36	48	60	70
5	L	20	36	50	56	70	13	L	16	24	34	52	68
	R	18	32	42	58	70		R	20	30	38	52	68
6	L	18	22	34	46	60	14	L	18	30	42	48	56
	R	16	28	30	30	42		R	18	30	36	48	60
7	L	16	24	36	58	66	15	L	18	32	48	52	64
	R	16	24	38	56	68		R	22	30	42	58	68
8	L	20	28	38	42	56	16	L	14	20	26	34	50
	R	16	24	36	44	64		R	16	26	34	44	56

Condition NA: Brain-Damaged

S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
						Eye							
17	L	10	14	20	32	40	25	L	20	40	42	50	68
	R	10	10	20	26	54		R	14	22	22	38	54
18	L	10	14	36	46	62	26	L	26	32	40	50	64
	R	10	24	42	56	78		R	10	18	30	40	58
19	L	10	20	32	48	56	27	L	18	28	48	52	70
	R	10	30	30	42	60		R	16	24	42	40	58
20	L	10	28	44	48	60	28	L	10	16	28	42	50
	R	12	22	40	40	58		R	10	12	22	28	56
21	L	10	22	40	40	66	29	L	18	28	44	44	56
	R	10	24	28	44	52		R	20	30	34	42	60
22	L	12	16	22	30	30	30	L	10	22	36	42	54
	R	10	14	36	42	54		R	10	16	24	32	40
23	L	22	26	38	46	58	31	L	10	12	22	32	48
	R	24	32	40	44	60		R	16	22	40	40	56
24	L	26	40	48	52	64	32	L	20	32	36	42	50
	R	16	28	40	42	54		R	10	16	28	36	54

Condition NA: Brain-Damaged

							Ear						
S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
17	L	24	24	36	56	76	25	L	22	28	40	42	56
	R	24	42	66	66	78		R	16	20	32	48	64
18	L	40	48	60	70	72	26	L	28	30	32	52	76
	R	32	38	38	42	50		R	20	20	38	52	68
19	L	20	36	38	56	70	27	L	22	26	42	50	62
	R	18	26	52	64	66		R	22	40	46	50	68
20	L	50	54	66	74	76	28	L	22	22	34	52	74
	R	50	64	70	80	84		R	20	38	40	52	70
21	L	18	20	32	32	54	29	L	22	22	34	46	62
	R	10	20	30	40	62		R	16	16	26	48	56
22	L	26	30	30	38	50	30	L	18	32	32	58	72
	R	30	34	42	56	74		R	20	38	48	60	74
23	L	20	32	48	52	74	31	L	20	28	40	44	64
	R	30	38	48	62	70		R	22	28	40	52	60
24	L	18	20	38	52	60	32	L	16	28	50	62	74
	R	16	38	40	46	66		R	14	24	46	58	70

Condition NA: Brain-Damaged

		Finger											
S#	Hemis. dB:	20	22	24	26	28	S#	Hemis. dB:	20	22	24	26	28
17	L	16	22	36	58	72	25	L	26	28	54	62	76
	R	14	20	34	56	70		R	22	32	50	60	74
18	L	54	58	56	62	64	26	L	18	26	42	62	76
	R	54	68	66	74	74		R	16	32	50	56	70
19	L	22	26	48	62	74	27	L	10	20	38	42	68
	R	30	36	50	66	62		R	18	24	40	56	80
20	L	18	32	50	52	68	28	L	20	40	52	60	74
	R	20	40	46	54	70		R	18	36	50	54	70
21	L	16	30	42	50	56	29	L	24	42	50	54	68
	R	32	32	60	54	70		R	10	18	32	58	60
22	L	30	38	42	58	62	30	L	12	30	32	58	76
	R	26	28	30	56	56		R	22	44	44	60	72
23	L	22	30	46	60	64	31	L	18	32	44	60	70
	R	18	32	50	56	72		R	12	24	38	54	68
24	L	30	48	50	62	74	32	L	14	22	32	40	64
	R	24	30	42	52	70		R	16	22	30	38	62

Condition A: Brain-Damaged

							Eye							
S#	Hemis.	dB: 40	45	50	55	60		S#	Hemis.	dB: 40	45	50	55	60
17	L	10	10	10	22	36		25	L	14	18	32	40	54
	R	10	10	10	20	30			R	16	16	24	36	42
18	L	10	14	34	50	62		26	L	16	20	32	40	48
	R	10	22	36	54	64			R	14	14	26	42	50
19	L	10	20	22	40	46		27	L	16	16	30	42	60
	R	10	26	28	40	54			R	12	20	22	36	52
20	L	10	22	32	40	52		28	L	10	10	14	30	36
	R	10	20	20	32	52			R	10	12	14	34	40
21	L	10	20	36	40	56		29	L	10	10	34	32	50
	R	10	10	18	20	34			R	10	10	28	38	52
22	L	10	12	20	30	30		30	L	10	10	30	30	46
	R	10	10	26	44	46			R	10	10	10	26	32
23	L	18	20	34	44	50		31	L	10	10	10	26	30
	R	16	30	32	40	52			R	10	10	26	28	40
24	L	16	24	32	40	52		32	L	10	10	20	28	42
	R	12	30	32	40	50			R	10	10	22	34	48

Condition A: Brain-Damaged

							Ear							
S#	Hemis.	dB: 40	45	50	55	60		S#	Hemis.	dB: 40	45	50	55	60
17	L	10	16	22	24	32		25	L	18	26	30	42	46
	R	22	30	36	48	50			R	14	18	30	50	58
18	L	34	56	44	52	66		26	L	18	24	30	52	60
	R	26	30	44	44	48			R	14	20	46	54	60
19	L	16	24	36	54	62		27	L	18	22	30	32	54
	R	10	20	34	26	42			R	20	20	36	50	64
20	L	16	28	50	64	74		28	L	18	18	24	32	46
	R	30	36	38	58	72			R	20	22	32	36	46
21	L	10	18	22	30	36		29	L	16	28	26	38	58
	R	16	26	26	40	48			R	10	10	20	36	50
22	L	16	16	24	30	34		30	L	10	14	26	52	60
	R	18	24	26	40	54			R	14	28	30	48	68
23	L	16	34	44	52	66		31	L	12	14	32	34	56
	R	22	34	50	52	66			R	12	20	20	36	54
24	L	16	16	32	46	52		32	L	10	22	32	26	44
	R	12	28	38	52	60			R	10	20	28	28	44

Condition A: Brain-Damaged

							Finger							
S#	Hemis.	dB: 20	22	24	26	28		S#	Hemis.	dB: 20	22	24	26	28
17	L	10	14	38	54	60		25	L	12	20	38	50	54
	R	12	16	40	56	62			R	16	28	40	48	66
18	L	26	30	34	40	40		26	L	18	18	22	32	64
	R	36	44	46	54	58			R	16	20	34	48	56
19	L	18	24	30	42	56		27	L	10	10	24	30	46
	R	10	16	22	32	34			R	20	22	38	40	72
20	L	10	20	20	32	40		28	L	12	20	26	40	52
	R	18	38	36	48	60			R	16	24	34	46	62
21	L	22	24	26	38	38		29	L	16	30	46	54	62
	R	26	24	30	34	60			R	10	10	26	40	44
22	L	14	14	22	36	46		30	L	10	22	40	54	64
	R	12	16	18	18	42			R	10	28	50	50	64
23	L	14	28	44	48	60		31	L	12	30	40	56	60
	R	20	22	42	58	62			R	10	14	30	52	60
24	L	22	36	48	60	62		32	L	12	12	30	38	56
	R	16	30	34	52	64			R	10	10	26	44	50

Condition IA: Brain-Damaged

S#	Hemis.	dB: 40	45	50	55	60	Eye	S#	Hemis.	dB: 40	45	50	55	60
17	L	10	10	10	20	24		25	L	16	16	32	42	52
	R	10	10	12	20	30			R	12	20	26	30	42
18	L	10	10	20	48	50		26	L	18	18	32	38	48
	R	10	14	40	50	70			R	14	16	24	42	46
19	L	10	10	26	32	46		27	L	18	20	32	40	60
	R	10	20	30	42	54			R	10	20	30	34	54
20	L	10	20	38	40	50		28	L	10	12	10	26	32
	R	10	10	22	32	50			R	10	10	12	34	38
21	L	10	10	30	44	54		29	L	10	10	20	34	48
	R	10	10	12	20	30			R	10	12	30	36	50
22	L	10	10	16	24	30		30	L	10	10	26	34	44
	R	10	10	24	36	44			R	10	10	12	22	30
23	L	18	24	36	44	52		31	L	10	12	12	28	28
	R	18	28	32	38	52			R	10	10	24	28	36
24	L	18	22	30	46	50		32	L	10	10	18	30	42
	R	14	30	28	40	48			R	10	10	24	36	48

Condition IA: Brain-Damaged

S#	Hemis.	dB: 40	45	50	55	60	S#	Hemis.	dB: 40	45	50	55	60
	Ear							Ear					
17	L	14	18	26	32	42	25	L	14	22	24	40	48
	R	24	22	32	48	50		R	14	16	32	50	62
18	L	40	42	50	60	68	26	L	18	18	30	50	64
	R	30	32	46	42	50		R	14	22	42	50	62
19	L	14	24	38	52	64	27	L	16	16	26	40	56
	R	12	18	28	30	36		R	20	26	32	52	64
20	L	26	36	40	52	58	28	L	16	18	24	36	48
	R	32	36	50	70	74		R	20	20	30	36	44
21	L	10	14	20	20	36	29	L	16	30	30	40	56
	R	10	20	30	42	50		R	10	12	10	36	50
22	L	14	16	32	32	34	30	L	12	12	22	50	60
	R	14	16	26	26	36		R	14	28	32	50	68
23	L	20	30	44	54	68	31	L	10	10	22	30	58
	R	24	42	50	56	64		R	10	14	22	32	58
24	L	16	20	28	42	50	32	L	10	20	26	30	36
	R	12	30	40	52	60		R	10	22	22	32	40

Condition IA: Brain-Damaged

							Finger						
S#	Hemis.	dB: 20	22	24	26	28	S#	Hemis.	dB: 20	22	24	26	28
17	L	10	10	36	56	66	25	L	10	22	40	50	52
	R	10	12	38	58	68		R	18	28	36	52	68
18	L	34	34	52	52	54	26	L	12	14	26	34	68
	R	40	44	48	48	56		R	18	18	32	48	54
19	L	14	28	28	44	58	27	L	10	10	22	30	42
	R	12	24	26	28	34		R	16	18	32	44	68
20	L	10	10	26	30	44	28	L	20	30	38	44	60
	R	10	28	38	50	58		R	18	24	30	44	64
21	L	14	20	20	26	34	29	L	20	38	38	52	62
	R	10	10	18	22	30		R	10	10	30	30	42
22	L	14	14	14	30	38	30	L	14	14	36	58	60
	R	14	18	18	22	24		R	14	38	38	50	68
23	L	20	38	38	50	58	31	L	12	18	50	52	60
	R	20	28	40	48	62		R	10	10	30	50	62
24	L	24	24	48	58	66	32	L	10	12	24	40	54
	R	16	32	38	50	66		R	10	10	20	36	54

APPENDIX B

EQUATIONS REPRESENTING THE PSYCHOMETRIC CURVES (LEAST SQUARE METHOD) UNDER VARIOUS EXPERIMENTAL CONDITIONS

Control

Condition	Eye	Ear	Finger
NA	y = .25x - 8.10	y = .24x - 7.36	y = .62x - 10.50
A	y = .23x - 7.87	y = .21x - 6.79	y = .53x - 8.96
IA	y = .23x - 7.66	y = .22x - 6.89	y = .58x - 9.84

BD

Condition	Eye	Ear	Finger
NA	y = .20x - 6.80	y = .22x - 6.63	y = .59x - 9.64
A	y = .18x - 6.25	y = .18x - 5.68	y = .49x - 8.37
IA	y = .17x - 6.08	y = .19x - 6.09	y = .50x - 8.67

APPENDIX C

DERIVATION OF AL, TOE AND THE ANALYSIS OF BACKGROUND AND FOCAL FACTORS

Derivation of AL, TOE and the Analysis of the Loadings n and e for B (background) and F (focal) Factors Respectively from the Psychometric Curve

$$AL = \frac{R - K}{C}$$

$$TOE = AL - F$$

where AL = adaptation level
TOE = time order error
R = neutral point in psychological scale
K = intercept of the psychometric curve
C = slope of the psychometric curve
F = geometric mean of the series stimulus

Two equations for solving the loadings n and e

$$nB + eF = AL$$

$$n + e = 1$$

where AL = adaptation level
B = geometric mean of the anchor stimuli
n = loading of B
F = geometric mean of the series stimuli
e = loading of F

APPENDIX D

AL AND TOE IN dB

Control

Condition	NA	A	IA
Eye AL	52.40	55.96	55.04
TOE	2.40	5.96	5.04
Ear AL	51.50	56.14	54.04
TOE	1.50	6.14	4.04
Finger AL	25.00	26.34	25.59
TOE	1.00	2.34	1.59

BD

Condition	NA	A	IA
Eye AL	59.00	62.50	65.18
TOE	9.00	12.50	15.18
Ear AL	52.87	59.33	58.37
TOE	2.87	9.33	8.37
Finger AL	24.82	27.29	27.34
TOE	.82	3.29	3.34

APPENDIX E

AUDITORY THRESHOLD

Auditory Threshold in dB (re .0002 dyne/cm^2)
to 1000 cps Pure Tone Signal

S#	Left ear	Right ear	Mean
1*	6	2	4
2	4	10	7
3	0	0	0
4	-4	0	-2
5	2	4	3
6	10	6	8
7	14	6	10
8	-2	-4	-3
9	4	4	4
10	10	2	6
11	4	6	5
12	8	4	6
13	0	4	2
14	4	2	2
15	2	6	4
16	10	8	9
17**	6	6	6
18	4	2	3
19	14	6	10
20	4	4	4
21	2	2	2
22	2	6	4
23	2	10	6
24	4	8	6
25	6	-2	2
26	-2	2	0
27	4	2	3
28	8	6	7
29	2	6	4
30	8	4	6
31	6	10	8
32	8	2	5

* S# 1 - 16 are control
** S# 17 - 32 are BD

APPENDIX F

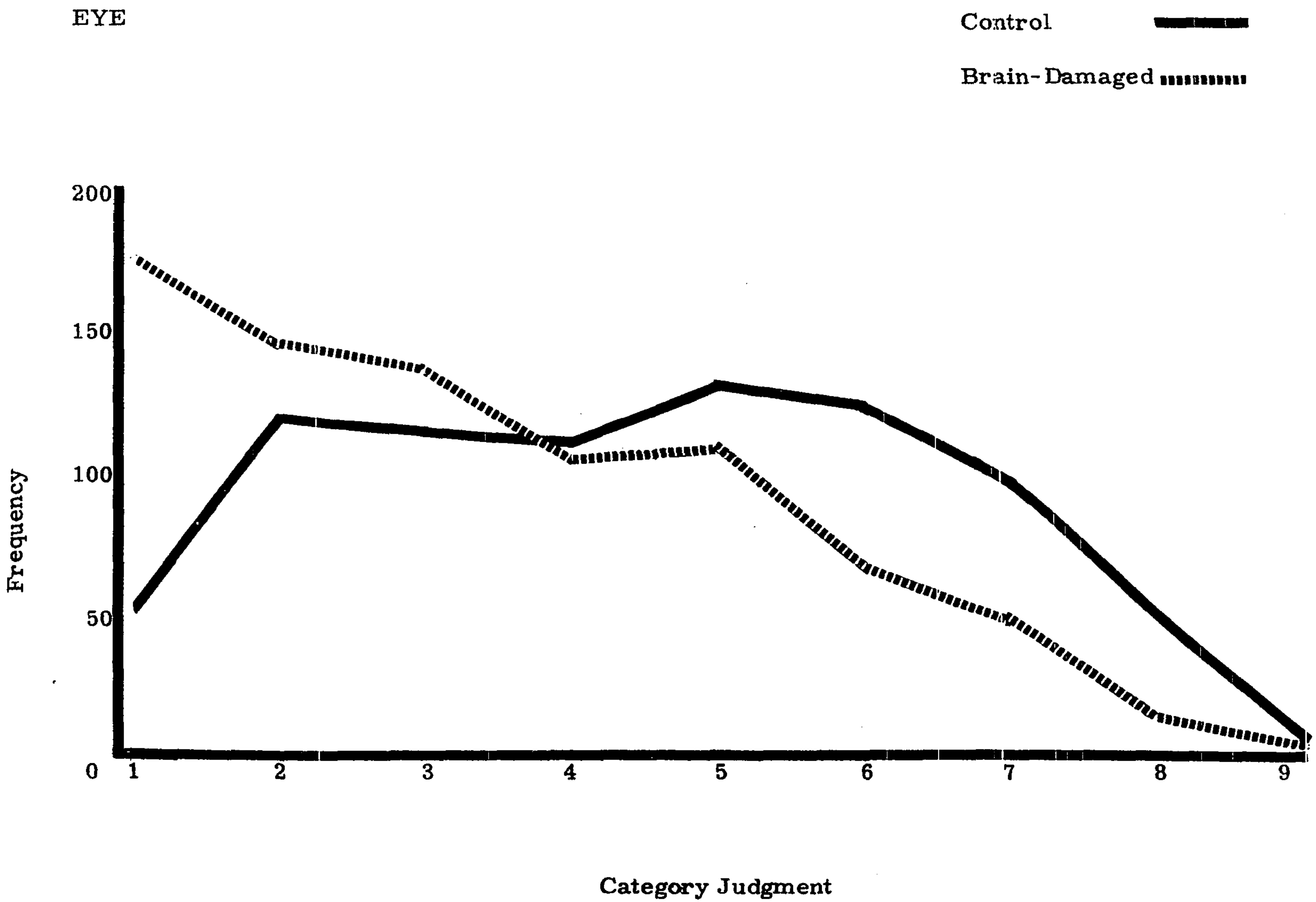
VIBRATORY THRESHOLD

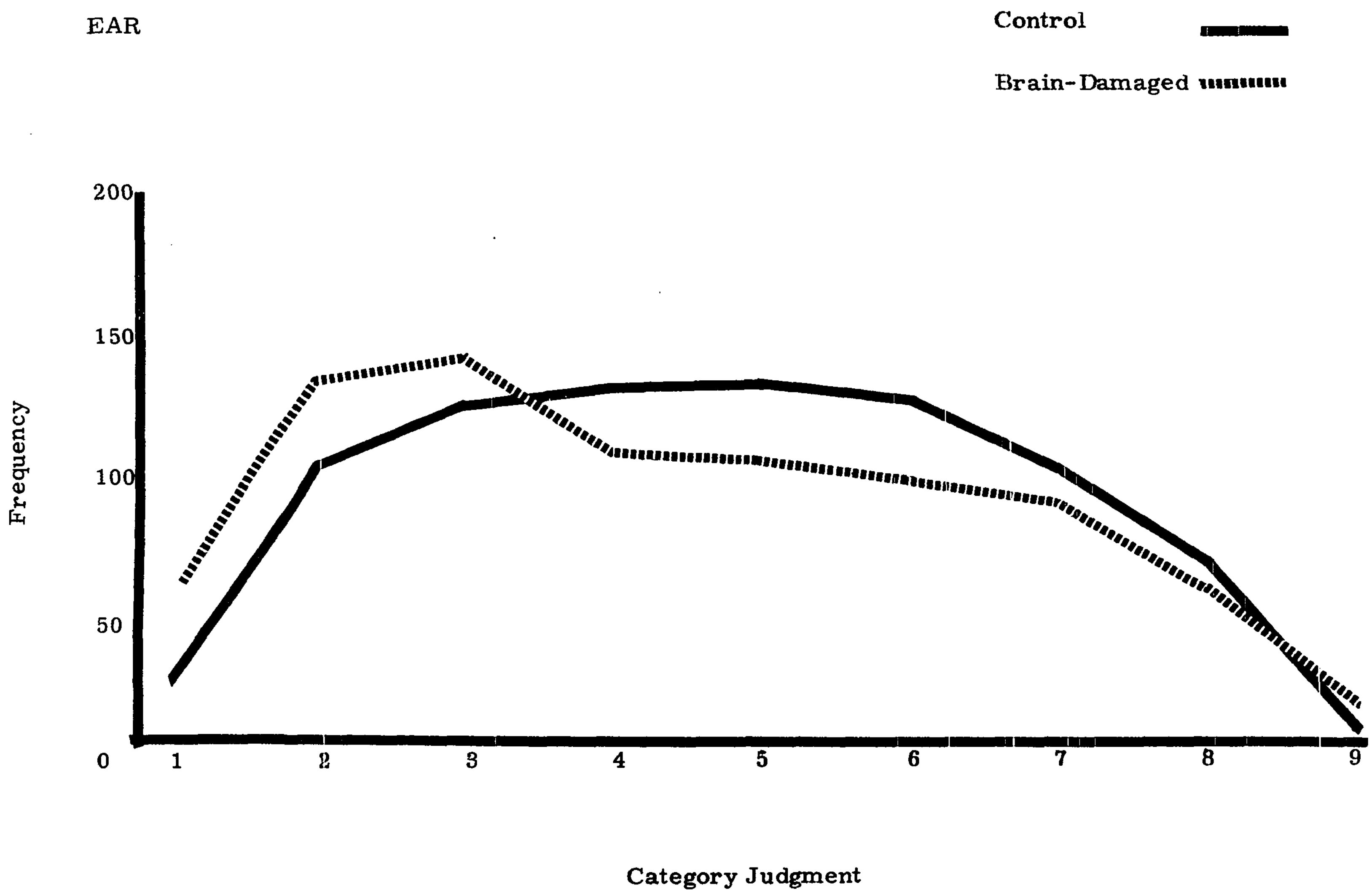
Vibratory Threshold in dB (re: 1 dyne) to 200 cps
Vibratory Signal

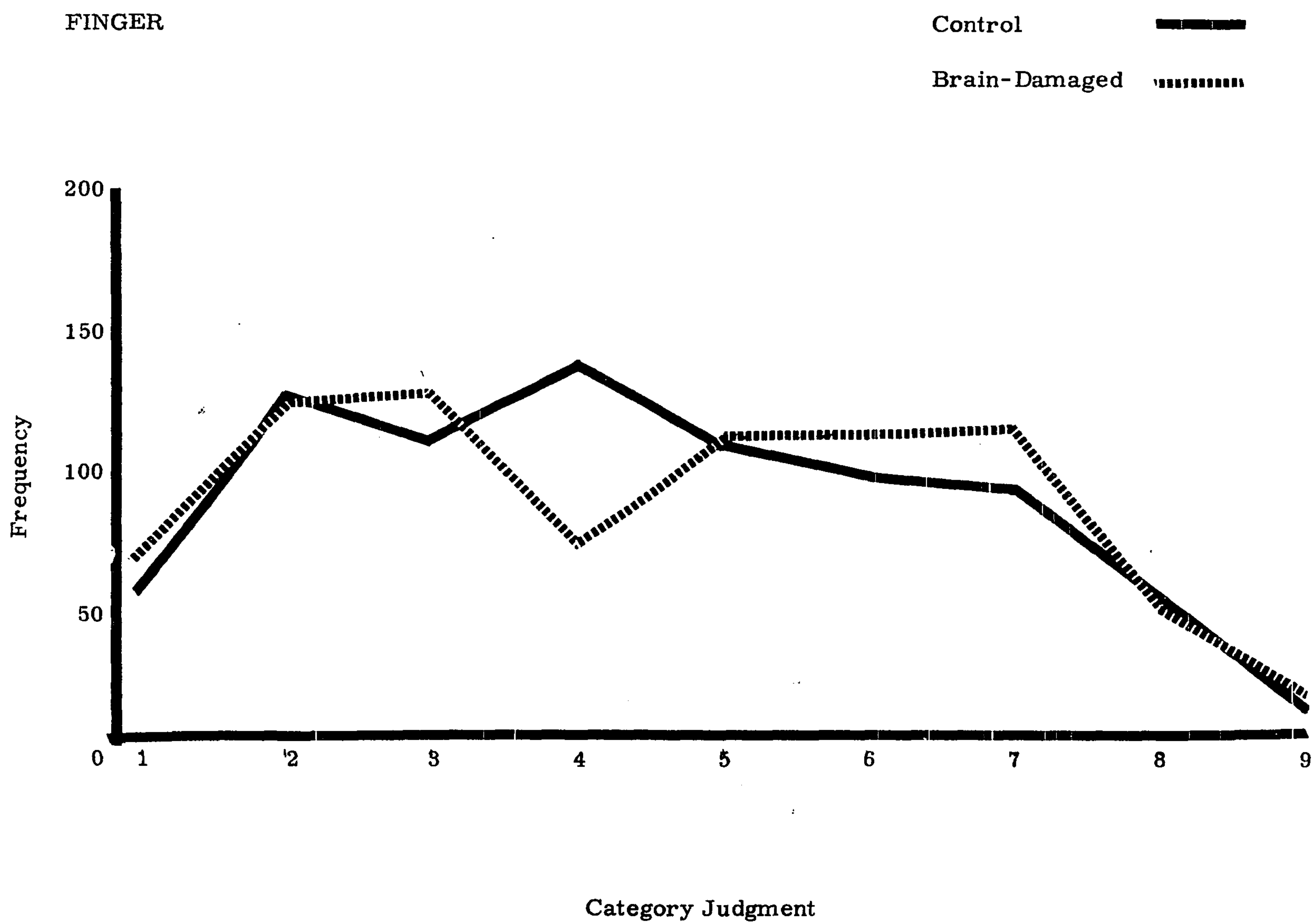
S#	Left finger	Right finger	Mean
1	38	22	30
2	34	40	37
3	60	40	50
4	52	28	45
5	38	58	48
6	38	52	45
7	56	46	51
8	34	30	32
9	42	28	35
10	50	30	40
11	46	34	40
12	30	40	35
13	60	46	53
14	52	44	48
15	22	34	28
16	40	44	42
17	44	56	50
18	40	42	41
19	46	54	50
20	42	28	35
21	46	64	55
22	20	32	26
23	54	30	42
24	38	46	42
25	58	48	53
26	32	42	37
27	62	50	56
28	32	40	36
29	46	56	51
30	38	26	32
31	40	38	39
32	38	50	44

APPENDIX G

CURVES SHOWING THE DISTRIBUTION OF CATEGORY JUDGMENT IN CONDITION NA


EYE
Control
Brain-Damaged
200
150
100
50
0
Frequency
1
2
3
4
5
6
7
8
9
Category Judgment


EAR
Control
Brain-Damaged
Frequency
200
150
100
50
0
1
2
3
4
5
6
7
8
9
Category Judgment


FINGER
Control
Brain-Damaged
200
150
100
50
0
Frequency
1
2
3
4
5
6
7
8
9
Category Judgment