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# SOME EFFECTS OF CONDITIONED FEAR ON STIMULUS GENERALIZATION

by

Arthur Robert Platz

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of the requirements for the degree of
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Doctoral Committee:

Associate Professor Robert B. Zajonc, Chairman
Professor Gerald S. Blum
Professor Dorwin Cartwright
Professor Daniel Katz
Associate Professor Donald E. P. Smith

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# CHAPTER I

## INTRODUCTION

In a review of recent research on learning Kendler (1959) proposed that "perhaps drives can energize behavior in a number of ways: by lowering thresholds, by facilitating response evocation, and by activating the association itself." This quotation briefly summarizes the basic question which fifteen years of research on the effects of motivation on perception have focused upon: do motives and drives affect what the perceiver sees or what he says? More precisely, are the experimental results due to the effect of drive on the stimulus or the response component of habit strength (sHr)? If nothing else, this research has shed new light on the response biases of experimental psychologists. In general, the learning theorist when confronted with the data has tended to use language implying the distortion of the response to an unchanging stimulus, while the personality theorist has explained the same data by implying a distortion in the perception of the stimulus. If one defines perception as the process of locating a stimulus in the multidimensional attribute structure of the perceiver (Birch, 1958), then the problem of motivational effects on perception may be reformulated: Do the perceiver's motives change the scale value of stimuli (Dorfman, 1960)? Under this formulation the critical task is that of defining the conditions under which changes in the indicator response of perception may validly be taken to mean a corresponding change in the scale value of stimuli.

Methodological problems inherent in the study of perceptual phenomena have recently received considerable attention. Garner, Hake,

and Eriksen (1956) distinguish between perceptual experience as an intervening variable and the perceptual response from which it may be inferred. In a similar vein Goldiamond (1958) discusses the "indicators of perception" and the limiting factors which may, in some cases, make these perceptual responses poor measures of the subject's sensory experience. Briefly, this argument runs as follows. Sensory input and the perceptual response indicator are highly correlated but extra-perceptual factors may reduce this correlation. Anything which affects the availability of the response such as frequency of usage, experimentally induced set, or the arousal of drive states which selectively cue off or inhibit certain responses may produce changes in the response hierarchy independent of changes in the sensory experience. These same factors are discussed by Bruner (1957) and Postman (1953) as determiners of the perceiver's "hypotheses" or states of perceptual readiness with which he approaches the experimental task. The effect of these extra-perceptual determinants is to produce variance in the response measure which is not related to changes in the perceived stimulus.

In reviewing the literature, major attention will be paid to the problem of these extra-perceptual variables, and to the possibility that the obtained experimental effects may be adequately handled in these terms without the necessity of postulating a perceptual effect of drive. Essentially we are asking whether the experimental manipulations affect what the perceiver sees or what he says in order to determine whether the data are to be given a perceptual or a response interpretation. Five kinds of data which are relevant to the question of drive-perception interaction will be considered: (1) accentuation

of perceived magnitudes; (2) effects of values and needs on recognition threshold; (3) effects of vigilance and defense on recognition threshold; (4) sensory interaction; and (5) effects of warning signals on threshold. In the final section of this chapter an attempt will be made to interpret those studies in which the examination of the response measure from which perceptual changes were inferred failed to show any obvious sources of variance beyond those attributable to the experimental manipulation.

## Accentuation of Magnitude Studies

Although there were historical antecedents (Ansbacher, 1937), the classical study in the area of accentuation of magnitude is by Bruner and Goodman (1947). Presenting coins to children in a size estimation task, they found that coins in comparison to cardboard discs tended to be overestimated as an increasing function of the coin value. Since the effect was also greater for children from poor families than from rich, they concluded that subjective need increases the apparent size of need related objects. Within a period of seven years other studies had shown size accentuation to be related to the incentive value of the standard stimulus (Lambert, Solomon, and Watson, 1949), states of deprivation (Klein, 1954), shock condition (Bruner and Postman, 1947), affective symbols embossed on the discs (Bruner and Postman, 1948), and to personality characteristics of the perceiver (Klein, 1954).

The same time period saw its share of negative results. Carter and Schooler (1949) failed to confirm the original Bruner and Goodman study in several important respects. In general, they found accentuation to vary with coin size rather than value, with the smaller coins actually

being underestimated. Bruner and Rodrigues (1953) in attempting to account for these discrepancies added to the confusion by finding that sizes of metal discs were overestimated more than coins, but saved the day by pointing out that if a relative score is used, coins show a significantly greater increase in percent of overestimation. This relative accentuation effect pointed out by Bruner and Rodrigues means only that the difference between the mean judgments of coin size and disc size tended to decrease as coin size became larger. The penny and nickel were underestimated relative to the discs, but the quarter was overestimated. No attempt was made to account for either the relatively greater increase in coin size judgments or for the absolute over-accentuation of disc size. Klein, Schlesinger, and Meister (1951) obtained non-significant results in a replication of a Bruner and Postman (1948) study showing overestimation of discs with affectively positive and negative embossed symbols.

Tajfel (1957, 1959a, 1959b) has delivered the coup de grâce to any over-simplified interpretations of accentuation effects in terms of the affective significance of the stimuli for the perceiver. Arguing that the enhancement effect is only incidental to the more pervasive accentuation of differences which occurs (as in the experiment by Bruner and Rodrigues referred to above), he cites the work of Eriksen and Hake showing that discrimination becomes easier if the stimuli differ on more than one dimension. Since coins differ both in size and value, they should be more discriminable than discs; that is, the variance in the judgments of coin sizes will be smaller, and consequently the effective distance between coins greater. Weight may also serve as a relevant dimension. Holzman and Klein (1956) report

that identical sized metal discs differing in weight will be over-estimated as a function of heaviness if they are held while the judgment is made. It will be remembered that the subjects in the original Bruner and Goodman study held the coins in their hands. The Bruner and Rodrigues study also indicated that the heavier coins (5¢ and 25¢) were overestimated more when held in the hand than when placed on the table.

As a test of this interpretation, Tajfel (1959a) ran a series of three experiments. The task involved absolute judgments of a series of ten weights. In the first study, reward was associated with the lifting of the two lightest weights. Judgments under the value as compared to the neutral condition showed an underestimation in weight of the six lightest stimuli, and an overestimation of the four heaviest. The second study paired reward with the two heaviest weights, resulting in the overestimation of the six heaviest stimuli and under-estimation of the four lightest. In both tests the difference between the lightest and heaviest stimuli was accentuated under the value condition. In a third experiment when reward was paired with the lifting of the odd numbered stimuli, the judgments showed no consistent tendency toward either over or underestimation, nor did the enhancement of the difference between the two end stimuli occur. Turnbull (1959) in a similar study using size estimation as the task, found comparable results. Tokens after "largeness" reward were judged significantly larger than after "smallness" reward. These studies show that the association of value with a stimulus may produce enhancement, under-estimation, or have no effects, depending upon the experimental conditions.

Following Helson, Tajfel interprets his results as indicating that induced value caused the end stimuli to serve as an anchor for the subject's judgments. By contrast the opposite end stimulus also serves as an anchor, producing an opposite but weaker effect. Thus, instead of the judgments showing the usual centralizing tendency as was found in the neutral series, the ends of the distribution tended to be pulled out resulting in the accentuation of differences effect.

Perhaps the confusion rests in the assumption that value characteristics of stimuli necessarily have different perceptual consequences than any other stimulus attribute. Dember (1960) has pointed out that the classification of an object may often carry with it set inducing consequences. Thus, Harper (1953) found that the amount of background red required to merge a figure with the ground depended upon whether the figure was called a "reddish apple" or a "yellowish-orange oval." Illusions such as the size-weight illusion imply that the scale value of a stimulus on one dimension affects how it will be judged on a second. This effect even extends to social judgments. If people are seen as differing on one continuum, they may be seen as differing more than they actually do on a second. Studies on prejudice and stereotyping show that the classification of an individual as a member of a social group also affects how the individual is judged on personality traits assumed to be related to this grouping (Campbell, 1956). The effect of value on size judgments of coins may be only another instance of the "set inducing consequences" brought about by the classification of the stimulus in terms of a related dimension.

The studies on positive and negative symbols may also be open to alternative interpretations. Singer (1952) has reported that discs

with meaningful content figures were overestimated in comparison with discs with nonsensefigures or without figures. Bruner's and Postman's results showed overestimation of all three symbols (swastika, dollar sign, and a cross enclosed in a square) as compared to a blank disc, but significantly more overestimation of the tokens with positive and negative symbols. But since the symbols used also differ in meaningfulness, an unequivocal motivational interpretation cannot be placed on the results.

Two additional enhancement studies should also be considered since they are often cited as evidence of motivational effects on perception. Examination of the methodology employed in these two studies indicates that the action of drive may have been on the stimulus trace rather than on stimulus reception since both studies employed a procedure which involved adjusting a test stimulus to match an absent standard stimulus. Gilchrist and Nesberg (1952) tested subjects under four degrees of either food or water deprivation. Subjects first observed colored slides of need related or neutral objects for a period of fifteen seconds. The picture was then turned off, the illuminance setting changed, and turned on again. Subjects matched the illuminance to match the brightness of the previous exposure. The authors' findings indicate that increasing need gives rise to an increasingly positive time error in illuminance matches of need relevant objects but not of irrelevant objects. Two things might be noted about the experimental procedure. First, the drive level is the same during both presentations. If drive affects stimulus reception, the effect should have been identical for the two times that the stimulus was presented. Secondly, the method of presentation involved matching of stimuli presented

successively rather than simultaneously. The illuminance was being matched with the remembered brightness of the first stimulus rather than the perceived brightness. Thus the results may well have to do with the effects of drive on the consolidation of a memory trace rather than directly with any perceptual process per se.

In the second study (Beams, 1954) a similar procedure was used. Subjects first observed a food object for a period of five seconds. After presentation of the food object, subjects were instructed to adjust the distance of a photograph of the food until it appeared the same size as the real object. Pictures of liked foods were set at a closer distance by the subject than were disliked foods. Apart from failure to control for possible response effects, this study does not clearly separate drive effects on stimulus reception as compared to effects on stimulus trace. In fact, it might be argued that the same results might have been obtained without presentation of the food objects by simply instructing the subject to adjust the distance of the photograph until the pictured object appeared life-size.

The review of the accentuation of magnitude studies has been, perhaps, unduly critical of studies attempting to demonstrate the effect of stimulus incentive value on perception. These studies do, in fact, suggest that when the subject's motives are actively engaged in the perceptual task by the experimental instructions, enhancement effects may occur. Lysak and Gilchrist (1955) found that subjects who were told that they would be given the money if they were accurate in their size judgments of paper currency made larger estimates than those who were not. Singer (1952) reports significantly larger estimates

of discs under "if you had to bet" instructions than under "how they look" instructions. And Bruner and Rodrigues (1953), contrary to their expectations, found greater overestimation under "accuracy" sets than for "value" sets. The original experiments postulated a specific drive effect on the perception of need relevant objects; these results suggest that the drive effect is non-specific and may result in enhancement regardless of the personal relevancy or incentive value of the stimulus.

## The Effect of Personal Values and Needs on Recognition Threshold

Two classes of experiments will be briefly reviewed; those dealing with assessed values and needs, and those in which the need state is experimentally manipulated. The classic experiment of the first type is that of Postman, Bruner, and McGinnies (1948), who hypothesized a relationship between personal value systems, as measured by the Allport-Vernon scales, and recognition thresholds of value related words. This study brought with it an orientation new to experimental psychology: thresholds of high value words should be lowered by "selective sensitization"; thresholds for words representing low valued areas should be raised by "perceptual defense"; and for high valued words the subject should select words covaluant with the correct word during the pre-solution period because of "value resonance." The results were consistent with these hypotheses: high valued words had lower thresholds, and pre-solution guesses for the high value words tended to be "covaluant", and for low value words, "contra-valuant." Similar results were found by McClelland and Liberman (1949) using the need achievement index.

These experiments were immediately criticized on two grounds: (1) word frequency, which is related to recognition threshold, was not controlled; and (2) the use of an assessment instrument may have resulted in the selection of subjects on the basis of verbal habits which are common to both test situations. A clear-cut example of the latter may be found in a study by Eriksen (1952) reporting that subjects who forget words associated with failure also show raised thresholds to the same words when presented tachistoscopically. Translated, this means only that a negative response bias induced by an unpleasant experience makes the response less likely to occur both in a memory task and in a perceptual task in which the conditions of stimulus presentation are not favorable for correct recognition.

If we examine the method of scoring thresholds as determined by the method of limits, we can see that such failures in experimental control cast considerable doubt on most of the experiments in this area. In the method of limits, using a recognition response as the perception indicator, threshold is determined by the matching or congruence of the subject's verbal response with the experimenter's answer sheet (Goldiamond, 1958). Extraneous factors such as word frequency, familiarity or set which affect response probability will necessarily bias threshold determination by changing the probability of the correct matching of response with stimulus by chance alone. The more often a particular response occurs, the more likely it will match the stimulus on an early trial, thus producing a lower threshold determination. These may be considered non-perceptual factors in recognition since they operate not on the input itself (stimulus reception) but on the output (Dember, 1960).

The findings of Postman, Bruner, and McGinnies (1948) indicate high valued words did have a greater response probability: presolution guesses for high value words were covaluant and for low value words, contravaluant. This means simply that irrespective of the stimulus, the subject's initial guesses tended to be high value words. Newbigging (1960) has shown similar results. In a simulated recognition task using a blank white card as the stimulus, subjects were more apt to respond with words consistent with their dominant value area, and to give these responses more frequently. The rank order correlation between the value rank and the "recognition threshold" determined in this way was .83.

The only experiment which appears free of these defects is that of Atkinson and Walker (1956). Using a forced choice technique adopted from Blum (1954), they instructed subjects to give the location of the picture which stood out the most or was most clear. High need affiliation, as compared to low need affiliation subjects, selected the location of pictures of faces significantly more often, although the stimuli were exposed at below recognition threshold values. This seems to indicate a sensitizing effect of need which somehow enhances need related objects.

Several studies have shown that experimentally induced needs also affect recognition threshold. If one accepts the argument that drive stimuli selectively affect response probability by becoming differentially conditioned to need relevant words, then these studies are open to the same criticisms noted above. Wispé and Drambarean (1953) found lowered recognition thresholds for food relevant words but not for

neutral words for hungry subjects. But the deprived group also gave more need related pre-recognition guesses. Lazarus, Yousem, and Arenberg (1953) found a selective lowering of threshold for food pictures as a function of number of hours of deprivation when a free-response measure was used, but no relationship when a forced choice technique was employed.

Of the studies reviewed, only the experiment by Atkinson and Walker (1956) furnished evidence for a sensitization effect of drive. The other studies showed lowered recognition thresholds as a function of induced or assessed need but do not control for possible response effects and consequently cannot be used to infer a sensory or stimulus effect of drive. These studies do not answer the critical question of whether the presence or absence of the stimulus makes any difference in threshold estimations. The crucial experiment would seem to involve the comparison of threshold determinations between stimulus present and stimulus absent conditions. Goldiamond (1958) has demonstrated response effects on threshold determinations by varying word frequency; it remains to be seen whether the presence of the stimulus will produce any additional lowering of threshold not accountable for in these terms.

## Vigilance and Defense Studies

In reviewing the vigilance and defense studies, the defense findings will not be discussed partly for methodological and partly for theoretical reasons. In discussing the methodology of these experiments, Goldiamond (1958) remarks that "one would have to go far in the experimental literature to find a more invalid indicator of concept-perception than this indicator coupled with the method employed" (i.e., ascending method of limits with an initial total accuracy indicator).

The criticisms are similar to those voiced against the value-need studies: anxiety conditioned to responses may be expected to bias their occurence. Since the use of a total accuracy indicator must be scored in an all or none fashion, the scoring ignores the partial information which the subject may receive from the stimulus presentation (Bricker and Chapanis, 1953). If the naming of the stimulus has been associated with punishment or anxiety, this partial recognition may be sufficient to cue off anxiety leading to an avoidance of the verbal response.

When response probability is affected by extraneous factors, then the perception indicator is admitting a source of variance not attributable to presentation of the stimulus. And a drive-perception interaction cannot be demonstrated unless the effect is significantly greater than could be accounted for by drive produced biases in response probability. Almost the only experiments in this area which attempt to control for response biasing are those of Blum (1954, 1955) and Mathews and Wertheimer (1958) which use forced-choice techniques.

The second reservation is on theoretical grounds: even if threshold effects beyond those attributable to known changes in response probability can be demonstrated, their interpretations in terms of perceptual changes is not unequivocal. Hochberg, Haber, and Ryan (1955) demonstrated that the consequences of an extraneous fear inducing stimulus on recognition threshold was the same regardless of whether it was presented .5 seconds before or 1.0 seconds after exposure of the stimulus word. One might argue from this that the perceptual defense effect is a post reception change and, therefore, not properly speaking a perceptual

effect at all. Following this argument, the stimulus is received and arouses anxiety which interferes with the labeling of the perceptual experience. The defense effects - raised threshold and discrepancy between the GSR and verbal response - may be interpreted as a response interference phenomenon rather than a phenomenon reflecting differential sensitivity of different response systems. Eriksen (1960), in his review of the literature, failed to find any evidence for a response system more sensitive than the verbal response; and Naylor and Lawshe (1958) point out that when partial information and response suppression effects are controlled for, the subception effect, necessary for a defense interpretation, disappears.

Of the studies purporting to show a vigilance effect, only that of Blum (1954) includes the necessary experimental controls. Using a spatial forced choice procedure, Blum found a significantly greater tendency to pick the location of the traumatic picture as compared to the neutral picture after a sensitization procedure. Since the pictures were presented at an exposure duration below that necessary for recognition and the response was not subject to biasing, this seems strong evidence for a motivational enhancement effect on perception.

## Sensory Interaction

Sensory interaction refers here to changes in the psychophysical responses to a test stimulus when extraneous stimuli are presented concurrently. Two aspects of this phenomenon will be considered here: (1) physiological data showing neural interaction resulting from simultaneous presentation of more than one stimulus, and (2) psychological data on changes in perceptual experience resulting from sensory interaction.

In his discussion of neural correlates of behavior, Hebb (1955) postulated that sensory events have two aspects: (1) a cue function and (2) an arousal or vigilance function. The concept of arousal is similar to that of "generalized drive state" in behavior theory (Runquist and Spence, 1959) and is assumed to facilitate cortical functioning at moderate levels. In a more detailed review of the neural substrate of behavior, Samuels (1959) points out that all sensory modalities feed collaterals to the diffusely projecting reticular system, and that sensory input consequently may produce both an evoked potential in a specific sensory projection area and the arousal pattern characterized by the desynchronization of the resting alpha rythms. She concludes that "the arrival of specific sensory impulses in the cortex is not, in the absence of non-specific reticular activity, a sufficient condition for the conscious perception of these impulses." Since the collaterals from specific sensory pathways terminate in the reticular system in a converging fashion, and there is evidence to show that a single reticular unit may respond to input from more than one modality, it seems possible that sensory interaction effects result from a special kind of spatial summation of neural impulses.

Neurophysiological data support Hebb's and Samuel's contention that arousal facilitates reception. Stimulation of diffusely projecting thalamic nuclei results in generalized cortical activation and enhancement of the responsiveness of the projection area to subsequent sensory volleys (Li and Jasper, 1953). Hypothalamic stimulation interacts with specific sensory stimulation to produce intensification in the amplitude of the cortical response and an increase in the area from

which it may be recorded (Gelhorn, Koella, and Ballen, 1954). Since the amplitude of the evoked potential correlates with subjective reports of stimulus intensity, this physiological finding may correspond to the hypothesized drive effect on perception. Facilitation and inhibition effects may be seen even in the sensory cells: reticular stimulation has been shown to affect the size of a specific evoked potential at the cochlea (Galambos, 1956); and Granit (1955) has shown an increase in impulse frequency and duration of discharge of retinal cells to a test flash of light subsequent to stimulation of the midbrain reticular formation. Inhibitory effects of external stimulation have been shown by Hernandez-Peon, Scherrer, and Jouvet (1956) in cats. Electrical discharges recorded from the cochlear nucleus to a click were abolished by visual (sight of a mouse), olfactory (smell of fish), and nociceptive (shock to paw) stimulation.

Hebb's conception of an arousal function of sensory input which increases the activation level of the organism parallels the discussion of drive by Miller (1951) and Hull (1951) in which it is assumed that drive level is a monotonically increasing function of physical stimulus intensity. If any stimulus may elicit some degree of reticular arousal, then it may be argued that the sensory interaction studies are illustrative of perceptual effects of motivation induced by the drive properties of the extraneous stimulus. The physiological data discussed which show neural interaction resulting from simultaneous input to more than one sensory modality are consistent with such an interpretation.

London (1954), in his review of the Russian literature, concludes that all modalities undergo modification as reflected by the sensory

response under the appropriate application of an accessory stimulus. Ryan (1940) reports comparable findings in the American literature. Hartmann (1934) found that pitch and intensity discrimination were more accurate when made in a lighted rather than a darkened room. Since many of his subjects reported feeling more "alive" under the light, Hartmann ascribes this effect to a general energizing influence of the extraneous stimulation. In a similar study (Hartmann, 1933) comparable facilitation of visual acuity was found with aural, olfactory, tactual, and pain stimulation. Whether the extraneous stimulation produces facilitation or inhibition is said to depend on its saliency; that is, a light will augment the main stimulus when it is in the background, but act as an inhibitor when it is focal.

Although many of the earlier studies are difficult to evaluate because of inadequate statistical analyses and the use of a yes/no perceptual response indicator, recent studies confirm the drop in threshold produced by extraneous stimulation.[1] Dorfman (1960) reports a lowered threshold for tactual stimulation (mild shock) for two intensities of extraneous sound stimulation. Although a yes/no indicator was used, increasing drive did not result in a significant increase in the "yes" response for "blank" trials when the stimulus was not presented. Since the drive did not result in an increase in false positives, the experimental findings may be intepreted as a sensitization effect. In a series of studies Brogden, Gregg, Thompson, and Voss (1951, 1952, 1958) found a decreasing threshold for a 1000

[1]Generally the yes/no indicator has been criticized for having lower reliabilities than comparable forced choice techniques (Blackwell, 1953) and not allowing correction for possible false negatives (Goldiamond, 1958).

cps tone as a function of the intensity of a concurrently presented light patch. When threshold determinations were preceded by a sensory conditioning procedure (pairing of tone and light), there was a proportionately greater lowering of threshold. Comparison of false positives, stimulus absent trials in which the subject reported the occurrence of the stimulus, between the experimental and control groups yielded no significant differences. The experimental instructions which defined the subject's task were an important determinant of the sensory effects. Subjects told to report if they heard the tone showed a facilitation effect with presentation of the extraneous light; subjects told to report the presence of the light as well as the tone, showed decreased auditory sensitivity. The decrement may be related to the order in which subjects were instructed to report the stimuli. Lawrence and LaBerge (1956) found that if subjects are presented with stimuli differing on several dimensions, accuracy of recognition varies with the order in which the attributes must be given. This effect occurs even if the order in which the attributes are to be given is not told the subject until after stimulus presentation.

Effect of warning Signals on Stimulus Thresholds

Studies on the effects of warning signals on threshold determinations generally report that the degree of facilitation increases as the interval between the warning signal and stimulus approaches zero (Child and Wendt, 1938; Howarth and Treisman, 1958). Recently, however, Treisman and Howarth (1959) found lowered thresholds even when the "warning signal" was presented up to .5 seconds after the stimulus.

Maximal effect was at simultaneous presentation and an immediately preceding signal (+ .1 second) slightly superior to a signal immediately (-.1 second) following the stimulus. Although a yes/no indicator was used, the false alarm rate was lowest when threshold was also at its lowest so that the changes do not appear to be response effects. This study precludes an interpretation in terms of a preparatory set brought about by the warning signal since facilitation also occurs when the signal is presented simultaneously or after the judged stimulus. It seems likely that this study, as well as the sensory interaction data, is best explained by assuming that the extraneous stimulation causes reticular activation (i.e., arouses drive) which, in turn, produces cortical changes reflected in increased rate of firing and greater amplitude of evoked potential which are associated with an increase in the perceived intensity of stimulation.

## Theories of Need-Perception Interaction

Before reviewing the experimental literature, the question was raised whether the experimental data supported the widely held view that motivational states affect perception. The data from each of the five areas reviewed indicate that the answer is tentatively in the affirmative. The theories generated to account for these findings, however, are more equivocal. In general, they tend to be specific to the data from which they are derived and, thus, cannot be used to account for results obtained by other data collection procedures. Secondly, the theories are so general as to generate few testable hypotheses. Most of the accentuation and vigilance and defense studies, for instance, have been demonstrational in character.

Perhaps the most commonly accepted interpretation of the perceptual effects is some variant of a "minimax" theory which holds that affectively positive stimuli are maximized or enhanced while unpleasant stimuli are minimized (Murphy's autism hypothesis, 1956, and early Postman, Bruner, and McGinnies, 1948). This theory has a face validity which makes it immediately appealing. People do, in fact, behave in a way to enhance pleasant and minimize unpleasant stimulation. Attempts to demonstrate this as a perceptual principle, however, have run into problems of response artifacts and negative instances. As stated, this theory cannot account for accentuation effects of negatively valued stimuli (Bruner and Postman, 1948) nor for vigilance effects evoked by anxiety arousing stimuli (Blum, 1954).

A more sophisticated variant of the minimax theory is the vigilance and defense hypothesis suggested by psychoanalytic theory. Changes in perceptual responses related to the operation of specific defense mechanisms (Lazarus, Eriksen, and Fonda, 1951) and to differences in ego functioning under different conditions of stimulus presentation (Blum, 1954) have been predicted and confirmed. Studies predicting perceptual differences from the assessment of individual defense mechanisms have generally been criticized on the grounds that the assessment instrument and the stimulus recognition task are both measuring correlated response biases (Postman, 1953; Goldiamond, 1958).

Bruner (1951, 1957) and Postman (1953a, 1953b) define perception as the categorization of stimulus input and explain motivational effects on perception in terms of factors which affect the accessibility of response categories. The major factor affecting the availability of

perceptual responses is the subject's "hypotheses" which are defined as states of expectancy or perceptual readiness, and which "are governed by general principles of associative learning" (Postman, 1953a). Thus, the accentuation of perceived coin size is now attributed to a learned association between value and size. Defense effects are interpreted in terms of motivationally induced hypotheses, or response biases, "rather than active repression of the....dangerous." Motivational selectivity of perceptual responses is emphasized but "little evidence for direct sensitizing effects of motivational conditions on perception" is found (Postman, 1953a).

The Bruner-Postman orientation has much to recommend it. It handles the accentuation studies and also the reverse effects which have been reported when reward is associated with smaller stimuli during pre-training (Tajfel, 1959; Turnbull, 1959). Their interpretation of vigilance and defense effects is similar to the commonly held interpretation in terms of response biasing (Eriksen, 1958; Goldiamond, 1958; Naylor and Lawshe, 1958). However, this orientation runs into problems in accounting for selective sensitization effects (Atkinson and Walker, 1956; Blum, 1954) since the effect does not appear to be attributable to response biasing or to "confirmation of a motivational or personality related hypothesis." Nor can it handle the results such as the sensory interaction data which seem to depend on a generalized arousal produced by extraneous stimulation.

The theories previously discussed have dealt with selective sensitization; needs affect the perception of need related stimuli, but not of irrelevant stimuli. In contrast, both Hebb (1955) and

Lindsley (1957) propose a generalized drive effect; moderate arousal enhances effective cue functioning by facilitating the cortical transmission and integration of sensory input. Several studies have confirmed this effect on simple psychomotor responses. Fuster (1958) found accuracy and speed of discrimination improved by moderate electrical stimulation of the brain stem. Lansing, Schwartz, and Lindsley (1959) report a decrease in simple reaction time which paralleled the course of alpha blocking produced by a warning signal. And Boswell (1958) found recognition threshold lowest during the ascending or excitatory phase of the alpha rhythm. As was noted earlier, there exists considerable evidence showing both facilitation and inhibition of the neural response to sensory input as a function of electrical stimulation of the reticular formation and by extraneous sensory input. Extrapolating from Boswell's data it might be predicted that threshold would also be lowered if alpha blocking were induced by extraneous stimulation. If this were indeed the case, the neural basis of sensory interaction effects, and perhaps accentuation and sensitization effects, might be found in the desynchronization pattern of firing which is related to cortical excitability and characteristic of the alert organism. However, these hypothesized neural correlates of accentuation and sensitization have yet to be demonstrated and are not directly suggested by Hebb or Lindsley.

In an effort to account for drive produced stimulus effects within a more inclusive theory, Dorfman (1960) has proposed an extension of the Hull-Spence behavior theory. In the theory as it now stands, drives and incentives are considered to have only response effects; that is,

change in drive level affects only the response component of sHr (Hull, 1943; Spence, 1956). In the proposed extension of the theory drive is also considered to have stimulus effects, or to effect the s component of sHr. Specifically, it is suggested that drives and incentives increase the effective value of a stimulus on an intensity dimension such that $S'=f(D,K,S)$, where $S'$ is the effective or perceived stimulus intensity, D the drive level, K stimulus incentive value, S the physical stimulus intensity, and the relation a monotonically increasing function (Dorfman, 1960). Since Dorfman's position predicts somewhat different perceptual consequences of drive than do the theories noted above, a more extended definition of the terms and characteristics of the theory are in order.

A. Physical Stimulus Intensity (S)

The concept of stimulus intensity dimension corresponds to the Hullian definition of dimensions to which the concept of V or stimulus intensity dynamism is related. In general, they are dimensions which are based on additive, rather than substitutive, changes in excitation (cf Stevens, 1957) so that the predicted changes in sensory experience are quantitative in nature rather than qualitative. Hull (1943) assumed that the physical intensity dimensions are functionally related to the rate of neural firing. As was noted earlier, the facilitation effects produced by reticular stimulation and by simulataneous stimulation of another sensory modality consist of increased rate of neural firing, duration of discharge, and amplitude of the evoked potential. These changes are usually assumed to be the correlates of quantitative changes in the perception of physical stimulus intensity (Samuels, 1959). Thus,

the physiological data on neural interaction are consistent with the psychological hypothesis of a drive-stimulus interaction which results in an enhancement of perceived stimulus intensity.

Although none of the perceptual theories discussed specifies the nature of the dimension on which the stimulus changes, in point of fact the measurement has always been on a quantitative dimension (usually size or heaviness in the accentuation studies and brightness in the vigilance and defense studies). The Bruner-Postman association theory has been tested on qualitative dimension (Bruner, Postman, and Rodrigues, 1958) but not with motivationally induced changes. This provides a critical test between the two theories. The drive-stimulus interaction hypothesis assumes that stimulus effects of drive are limited to changes in perceived stimulus intensity, while an association theory implies changes in qualitative judgments as well. This difference between the two theories will be further discussed.

B. Drive (D)

By drive is meant any state which is congruent with the Hull-Spence assumption that E=f(DxH). In order to account for the sensory interaction data within this theoretical framework, Dorfman has also argued that drive is a monotonically increasing function of physical stimulus intensity. This view is consistent with positions taken by Miller (1951) and Hebb (1955) and seems to satisfy the assumptions of the DxH relationship.

Although the drive-stimulus interaction hypothesis does not preclude a specific drive effect on the perception of need relevant

stimuli, these might also be handled more parsimoniously within the same general framework. If it is assumed that the perception of need relevant stimuli arouses an emotional response which acts as a generalized drive state (Spence, 1958; Runquist and Ross, 1959), then the effective intensity of these stimuli should be enhanced. That is, $S'=f(r_e,S)$, which is a specific instance of the $S'=f(D,S)$ relationship. Neutral stimuli would not arouse an emotional response and, consequently, would not be accentuated.

C. Effective Stimulus Intensity (S')

Within the Hullian framework effective or perceived stimulus intensity is not functionally equivalent to physical stimulus intensity. Hull (1951) differentiates between the "molar stimulus trace" and its stimulus equivalent. The former is identified as the afferent neural impulse and is assumed to change systematically over time or as a function of concurrent stimulation (afferent stimulus interaction). The drive-stimulus interaction hypothesis proposes that effective stimulus intensity also changes as a function of drive level, such that $S'=f(D,S)$. The implication for the Hull-Spence behavior theory is that drives not only affect the response component but also the stimulus component of sHr; and that response strength associated with a given physical intensity is a function of s'Hr not simply sHr.

Dorfman (1960) has discussed in detail how this hypothesis can account for the perceptual effects of drive discussed earlier. His presentation will be briefly recapitulated here. In determining the psychophysical threshold, the probability of a correct response is assumed to be a monotonically increasing function of effective stimulus

intensity. If drive increases effective stimulus intensity, then:

If: $S'=f(D,S)$ and $S'>S$,

Then: $Pr(R)S'>Pr(R)S$. (Where R is the correct recognition response).

The data from experiments requiring psychophysical judgments can be handled in a similar fashion. If the probability of reporting a test stimulus greater than the standard stimulus increases as a function of its magnitude and if the drive-stimulus interaction holds, then:

If: $S'=f(D,S)$ and $S'>S$,

Then: $Pr(G)S'>Pr(G)S$. (Where G is response "greater").

That is, under drive arousal the same physical stimulus will be judged greater than the standard stimulus more often than under relaxed conditions. The same implications follow if the motivational term K or incentive is substituted for D in the equations.

Although the drive-stimulus interaction hypothesis seems to adequately account for the effects of drive on threshold and judgment responses, the marks of a good theory are two-fold: (1) it should be congruent with the available data, and (2) it should lead to testable consequences. In the present chapter the experimental literature relevant to this theory and the alternative theories generated in an effort to account for the observed relation between motivational states and perceptual responses were examined. The hypothesis that drives increase effective stimulus intensity was presented and an attempt was made to show how this theory accounts for changes in threshold and

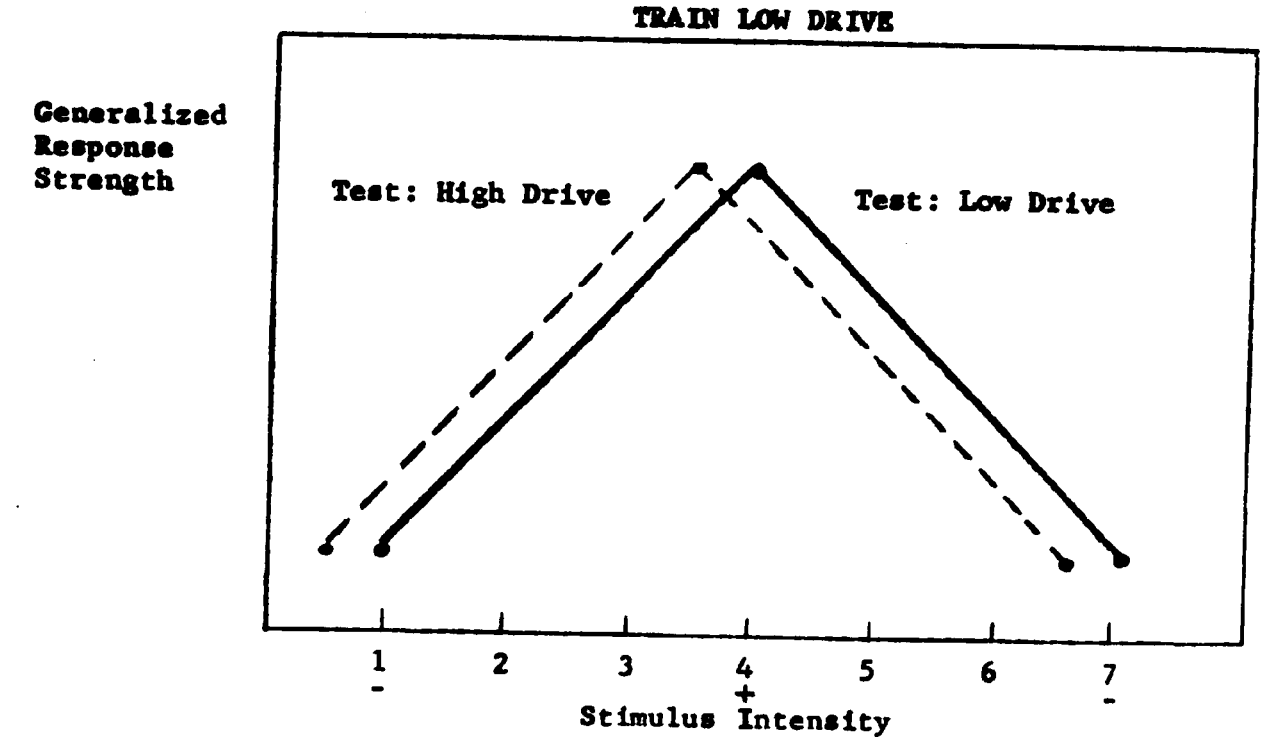
comparative judgments induced by drive arousal. In Chapter II one implication of the drive-stimulus interaction hypothesis in regard to effects of change in drive level on stimulus generalization will be discussed and the experimental test of the predictions presented. And in the final chapter implications of this theory will be examined with respect to the experimental areas reviewed here, and predictions from this theory will be contrasted with those made from a Bruner-Postman "hypothesis" theory and from the vigilance and defense theory.

## CHAPTER II

## THE EFFECTS OF CHANGE IN DRIVE ON STIMULUS GENERALIZATION

In the first chapter it was argued that perceived or effective stimulus intensity is a monotonically increasing function of drive: $S' = f(D,S)$. If effective stimulus intensity is a joint function of drive and physical stimulus intensity, the response strength associated with a given physical stimulus is a function of $s'Hr$ rather than $sHr$. Consequently, changing drive should have the same response effects as changing the physical stimulus. Since drive produces this effect by changing the scale value of stimuli, the mode and shape of generalization curves should depend upon the relationship between training and test drive levels.

Consider the following procedure: a stimulus dimension consisting of seven stimulus intensities from S1 to S7 is used. The subject is trained to respond to the middle stimulus, S4, by saying "hit" and to the two end stimuli, S1 and S7, by saying "miss." A test for stimulus generalization yields a roughly symmetrical gradient. If the subject is now tested at a higher drive level, the effective intensity of the test stimuli should be increased. This increment in effective stimulus intensity makes the smaller stimulus intensities more like S4 during training; therefore, the probability of response "hit" increases for these points. Conversely, S4, S5, S6, and S7 are now less like S4 during training because of this increment in effective intensity and the generalized response tendency "hit" decreases for these points. The net effect of increasing drive is to shift the entire gradient toward the smaller physical intensities. The opposite effect occurs when drive is decreased



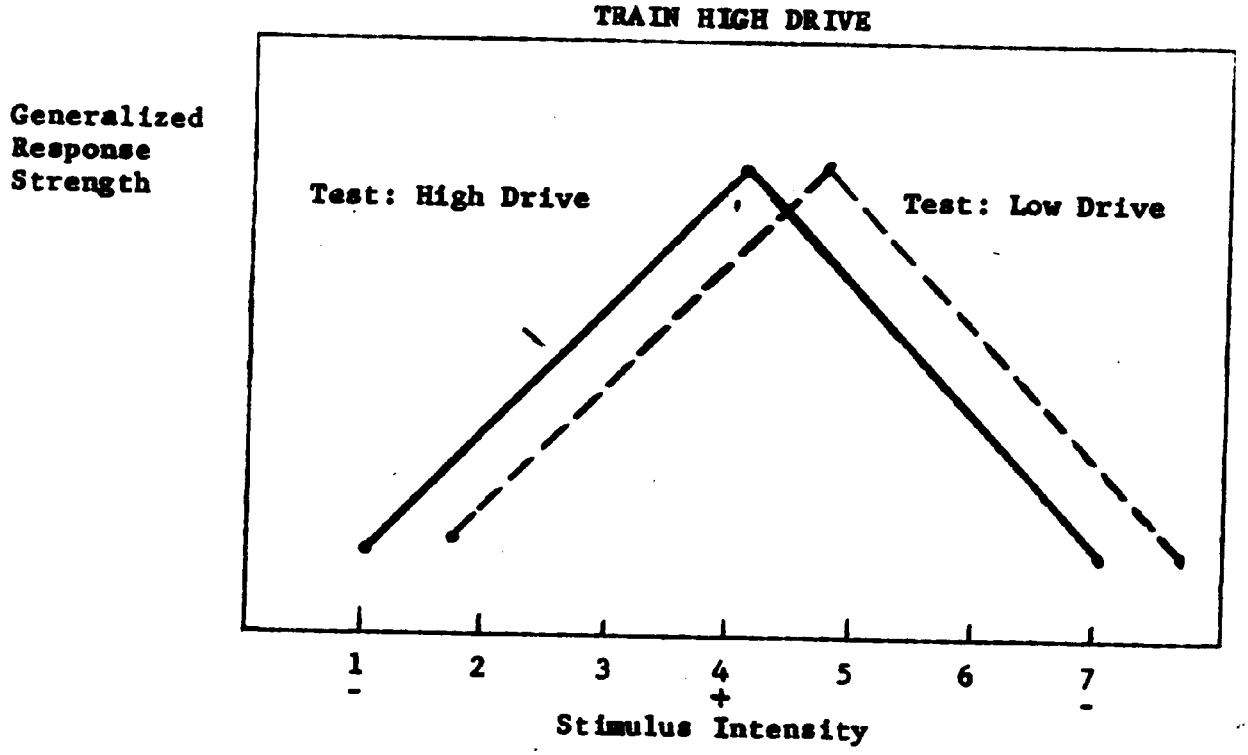




**Figure 1:** Predicted changed in generalized response strength associated with physical stimulus intensity under change in drive.

from training to test. Since lowering drive causes a corresponding lessening of effective stimulus intensities, each physical stimulus is now associated with the response strength of a smaller stimulus and the generalization gradient is shifted toward the larger physical stimulus intensities (Figure 1). It may be noted that either increasing or decreasing drive reduces the probability of response "hit" to S4 since in both cases its perceived intensity has changed from training to test.

Testing for stimulus generalization may be compared to psychophysical procedures of data collection. In the present instance, the probability of the response "hit" decreases as a function of the distance from the original positive training stimulus. In a psychophysical procedure such as the method of paired comparisons, the probability of response "same" decreases as the distance between the standard and comparison stimuli becomes greater. Both procedures, directly or indirectly, involve comparisons between stimuli and similarity judgments on the part of the subjects. Neither provides unequivocal information about the subject's state of awareness. Even when using a psychophysical procedure, for instance, perception may only be inferred from response probability. Available data indicate that psychophysical responses are as amenable to experimental manipulation as any other response. Goldiamond (1958) and Tanner and Swets (1954) have presented detailed discussions of factors reducing the congruence between stimulus occurrence and psychophysical responses. Eriksen and Wechsler (1955), using the method of absolute judgment, report that while random shocks delivered to the subjects did not affect their sensory capacity, as measured by bits of information

available in their responses, they did produce systematic response effects. Anxious subjects were both more biased in their use of the available responses and more stereotyped in the responses given to specific stimuli. It will be noted that these changes in the psychophysical response are identical to the response effects predicted by the Hullian hypothesis that drive energizes habit strength: (1) an increase in the probability of the more frequently occurring responses, and (2) a corresponding increase in the probabilities of the dominant responses to a given stimulus. That is, if the most likely response to stimulus 6 is response "six", increasing drive will multiply with habit strength to further increase its probability. This multiplication effect of drive increases the difference in effective reaction potential between alternative habits such that $Di(Ha - Hb) > Dj(Ha - Hb)$, where $Di > Dj$. The larger the initial difference between the two habit strengths, the greater the effect of drive on their relative probabilities. A graph plotting the frequencies of the different responses to a specific stimulus for Eriksen's and Wechsler's data would show this DxH effect in a heightened elevation of the curve, indicating the increased frequency of the dominant response; and a steeper slope, reflecting the relative decline in frequency of the alternative responses.

Although as a formal theory the terms in the drive-stimulus interaction hypothesis are operationally defined - effective stimulus intensity in terms of response probability, drive by a standard manipulation or a concurrently measured physiological response, and the physical stimulus intensity by a dial reading - it is tempting to

regard change in effective stimulus intensity as a sign of changes in perceived intensity, and consequently, the shift in the generalization gradient as an indicator response of a corresponding change in perception. In and of itself the statement that S'=f(D,S) says nothing about perception. It states only that for a given physical stimulus intensity, response probability varies as a function of drive level: for a given S, S'=f(D).

The argument might run as follows: if inferences of stimulus similarity can be made on the basis of the amount of generalization to adjacent stimuli, then the shift in the gradient toward the smaller stimulus intensities when drive is increased indicates that these stimuli are perceived as more intense at higher drive levels. Specifically, S1, S2, and S3 now more often elicit the response conditioned to S4, and the larger stimuli, S5, S6, and S7 elicit it less often. A similar interpretation may be made of the response changes produced by decreasing drive level from training to test.

In order to properly evaluate whether a shift in the generalization gradient can serve as a valid indicator of perceptual change, drive produced response effects not attributable to sensory changes should be considered. Although there have been many studies of stimulus generalization as a function of drive level (cf. Mednick and Freedman, 1960), there have been few studying the effects of changing drive level from training to test (Estes, 1958). Rosenbaum (1953) found that the generalization gradient of a motor response along a height dimension was elevated by the arousal of an irrelevant drive. The possible effects of reducing drive level were not investigated. Almost the

only experiments falling into this category are those done in the program of research which include the present study.[1] Dorfman (1960) studied the effect of changes in irrelevant sound on stimulus generalization along a tactual intensity dimension (mild shock). Although the generalization gradients shifted as predicted, the analysis of variance attributable to training drive level was not statistically reliable because of the displacement of the training curves. The median of the low/low curve was significantly displaced to the right of the high/high curve, such that the curves obtained for Ss under the low/high condition were not reliably different from those of Ss trained and tested under the high/high condition. These data suggest the possibility that an important variable operating is the drive level during testing rather than just the change in drive level. A recent

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[1]The studies to be discussed employ the following design: two groups of subjects are used, one group trained under low drive, and the second, under high. Both groups are then tested for stimulus generalization at low and high drive. To simplify presentation, the major test conditions are labeled as follows:

| | | Test Drive: Low | Test Drive: High |
|---|---|---|---|
| Training Drive | Low | low/low | low/high |
| | High | high/low | high/high |

The first term refers to the training drive, the second to the test drive. Generalization curves obtained when the subject is tested under the same drive level as maintained during the original training will be referred to as the training curves. Curves obtained following a change in drive from training to test trials will be referred to as the experimental curves.

study by Jenkins, Pascal, and Walker (1956) on the affect of drive on stimulus generalization along a light intensity dimension provides some support for this argument since the curves obtained for pigeons trained and tested under high drive were also displaced to the left of the curves obtained for a group trained and tested at low drive. In Dorfman's study the test drive effect was significant beyond the .001 level. The fact that the low/high curve is to the left of the high/high curve might be explained, in an admittedly ad hoc fashion, as being due to the attenuation of the drive producing properties of sound through its repeated presentation during training.

In another study in this series, Matlin (1960) manipulated drive by having subjects squeeze a spring dynamometer arranged so that muscle tension was maximal at the onset of the judged stimulus. The generalization curves along a sound intensity dimension shifted in the direction opposite to that predicted by the drive-stimulus interaction hypothesis. Again, there was a marked displacement of the training curves, and again the change in drive level produced a shift in the gradient away from the initial displacement of the training curves. However, perhaps equally important in interpreting the effects obtained, is the nature of the drive manipulation. High drive was defined as a pull of two-thirds maximum strength. Since the relay switch controlling the presentation of the stimulus was located on the dynamometer dial, Ss may have been watching the dial to determine how much more pressure was needed to complete the circuit. The nebulous factor of "attention" is well-known to be crucial in any test demanding a psychophysical response. Lawrence and LaBerge (1956) report, for instance, in a

study of recognition accuracy of multi-attribute stimuli, that instructions to "pay attention" to one dimension resulted in a considerable enhancement of accuracy for this dimension in comparison with the other two. Even instructing subjects after stimulus presentation the order in which dimensions were to be named markedly affected accuracy. In a study cited previously, Gregg and Brogden (1952) reported that extraneous light stimulation improved auditory sensitivity. But when subjects were instructed to report whether the light stimulus occurred on specific trials, auditory threshold was raised. There is the possibility, then, that the procedure used by Matlin may have had the extraneous effect of distracting the subject from attending to the sound stimuli so that the stimuli were actually perceived as being less intense under strong drive with the result that the low/high curve was displaced toward the larger physical stimulus intensities.

Similar reservations may be made concerning the study by Zajonc and Platz (1960) in which the high drive condition was produced by placing a large box of penny candies in front of the child with the promise that if he were accurate, he would receive five pieces of candy after each block of seven trials. The experimental results were similar to those reported by Matlin. Again, it may be argued that the manipulation of drive served mainly to distract the subject from the experimental task. Presuming that candy is highly salient for children, their attention may have been directed more to the candy box, and possibly to silently rehearsing their choices, than to the sound stimuli. Although labeling a drive manipulation as distracting

begs the question, it may be translated to mean that the arousal of drive results in a greater relative increase in the probability of a rival habit which interferes with the orienting response to the test stimuli. Given this translation, it may be predicted that using a dynamometer to control stimulus presentation in a signal detection task would result in a raised threshold under the high drive condition.

Although the effects of the drive manipulation in the three studies reported are contradictory, the results do have two features in common: (1) in each of the studies there was a substantial difference between the two training curves, and (2) the shift produced by changing drive was in the direction away from the initial displacement. In the light of these findings two questions suggest themselves. (1) Is the initial displacement related to drive level? (2) Can the shifts in the generalization curves be attributed solely to the drive level during testing if the additional assumption is made that high drive training produces some adaptation of the drive arousal properties of the drive manipulation. More attention will be addressed to these two questions in considering the findings of the present study. Suffice it to add here that Dorfman (1960) has handled the first problem within a drive-stimulus interaction framework by assuming that the functional relation between drive and stimulus intensity may be such as to result in a greater increase in the distances between the smaller physical intensities than between the larger ones. If Dorfman's analysis is correct, there is no reason for believing that changing drive produces any effect other than that attributable to the drive level present during testing since one cannot specify that testing at a high drive is

equivalent after high as compared to low drive training. It seems clear that no matter how drive does produce displacement, changing drive level, by reversing whatever effect produced the initial training curve displacement, should shift the curves in the opposite direction. While this interpretation of these experiments is ad hoc, it is consistent with a drive-stimulus interaction theory and does lead to testable predictions about stimulus generalization and discrimination learning which will be discussed in Chapter III.

A remaining study to be discussed is of considerable interest because it uses a single training point generalization procedure rather than the - + - discrimination procedure used in the three preceding studies, and investigates the effect of test drive and change in drive along a qualitative dimension where stimulus effects of drive would not be expected to occur. Thomas and King (1959) tested for stimulus generalization along a light frequency dimension as a function of changes in drive between training (pigeons at 80% body weight) and test (60, 70, 80, and 90% body weight). Generalization increased monotonically with increases in test drive, with both increase and decrease in drive producing flatness on both wings. A second study to test specifically whether change in drive produces flattening in the gradient of stimulus generalization was run on three groups of birds trained and tested at 70/70, 80/80, and 80/70 percent body weight. The two groups tested at the higher drive had almost identical gradients. The group trained and tested at the lower drive showed marked differences in stimulus generalization compared to the group trained and tested at the higher drive. The

slope of the former was much steeper, with a higher peak at the training stimulus. The authors conclude that the shape of the generalization curve is a function of drive level during testing and independent of the drive level during training. Although no analysis was made, the curves presented show no indication of displacement as a function of test drive level or change in drive level from training to test. Thus far, then, the displacement of generalization curves produced by changing drive has only occurred when quantitative dimensions have been used.

The present experiment is an extension of the previous work testing the drive-stimulus interaction hypothesis and focuses upon two problems raised by these studies: (1) the nature of the drive manipulation used to obtain the drive-stimulus interaction effect, and (2) the question as to whether the shift in the generalization curves is attributable to the effect of drive level during testing or to change in drive from training to test. The original formulation of the drive-stimulus interaction hypothesis predicted a displacement of the curves following changes in drive level. But given the initial displacement of the training curves, the shift may be equally interpretable in terms of test drive level alone. Given this initial difference, the experimental design used in the previous studies does not allow for separation of these two factors.

The initial study in this series (Dorfman, 1960) used high and low intensity sounds to induce drive and studied generalization along a tactual intensity dimension. Since the sound was presented concurrently with the tactual stimulus, the results may be looked

upon as a special case of sensory interaction using a generalization procedure in place of the more common psychophysical methods. It was felt that the use of a response produced drive would give the hypothesis more generality and extend the research beyond the sensory interaction paradigm. In place of the primary drive aroused by intense sound stimulation a strong learned drive (conditioned fear) was used. The present test is of a predicted interaction between external stimulation and an internal drive state assessed by means of the GSR.

In previous studies drive has been defined solely in terms of a standard experimental manipulation. A more rigorous test of the drive-stimulus interaction hypothesis is possible if drive strength is assessed at each stimulus presentation. Recently, there has been considerable interest in attempts to define drive in terms of concomitant physiological responses rather than by antecedent operations (Malmo, 1958, 1959). Perhaps the most commonly used physiological measure assumed to be correlative with drive level has been the galvanic skin response (Lindsley, 1951). Partly in response to these studies, Spence (1958) has presented a theory of emotionally based drive in which it is assumed that an internal emotional response ($r_e$) is functionally related to drive (D). Predictions from this theory have been tested and confirmed in studies relating differences in skin conductance to performance in eyelid conditioning (Runquist and Spence, 1959; Runquist and Ross, 1959).

The use of the GSR measure in the present study provides an external check on the validity of the drive manipulation and makes possible two partially independent definitions of drive: (1) as an

antecedent operation such that responses to a positive CS for fear constitute high drive trials, while those responses to a negative CS make up the low drive trials; and (2) by the magnitude of the GSR shown on a given trial.[1] If $S'=f(D,S)$ is true, $S'=f(r_e,S)$ is a necessary consequence given that $D=f(r_e)$. Generalized response probability to a given stimulus should show certain predictable relations to the magnitude of the GSR elicited by the CS on those trials. The GSR as a concurrent measure of drive would also make possible an assessment of the experimental effects attributable to the absolute test drive level and those attributable to changes in drive from training to test which the design of the previous studies has not made possible. Since the GSR provides a measure of drive for both training and testing trials, it may be scored in two ways. It will provide a measure of absolute drive level during testing, and also a relative measure reflecting the change in drive from training to test. Since the GSR is distributed continuously, it allows a type of analysis not possible with the two category scoring of the drive manipulation in terms of high or low drive. With these two GSR scores one may ask whether drive level at testing or change in drive level from training to test provides a better predictor of the displacement of the generalization curve. And by examining the training curves one might also test, for instance, whether the position or displacement of the high/high and low/low curves may also be related to changes in drive level even when the drive manipulation is constant.

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[1] The use of the GSR as a criterion measure of the drive manipulation was suggested by Dr. David Birch.

In summary, the experiment reported here is part of a research program concerned with the effects of changes in drive on effective or perceived stimulus intensity. The procedure used to test the major hypotheses differs from that of previous studies (Dorfman, 1960; Matlin, 1960; Zajonc and Platz, 1960) only in the antecedent operation defining drive. The purpose of the present study is two-fold. First, it extends the research beyond the study of the perceptual effects of primary drives (sound and muscle tension) by using a secondary or learned drive (conditioned fear). And secondly, it provides a physiological measure of drive strength for each stimulus trial. The drive manipulation makes possible a test of the hypotheses that $S'=f(D,S)$; the physiological assessment of drive allows, in addition, a test of the similar hypothesis that $S'=f(r_e,S)$. The physiological assessment of drive also makes possible an answer to a question raised by previous studies, namely, whether the observed changes in stimulus generalization are due to changes in drive from training to test or are simply due to differences in the level of drive during the test trials.

## METHOD

Subjects: Forty one students (39 males and 2 females) from the University of Michigan were used; twenty-one were trained under high drive and twenty under low. An additional twenty subjects were used for pre-testing the conditioning procedure and the selection of stimulus points to be used for testing for stimulus generalization.

One subject from the train high group was discarded due to failure to obtain GSR conditioning. Seven subjects did not

complete training because of failure to learn the autitory discrimination or unwillingness to tolerate the shock level used during fear conditioning.

Apparatus: A Hewlett-Packard audio-oscillator was used to present different intensity tones of 1000 cps through rubber cupped earphones. Shock during fear conditioning was administered to the left forearm by means of a standard "Stimulator" (Model 935B, Harvard Apparatus Company). Changes in skin conductivity during the experimental session were recorded by means of a Fels dermohmeter (Model 22A, Serial #117; Yellow Springs Instrument Company, Inc.) from the right palm of the reclining subject.

During fear conditioning two identical 7.5 watt bulbs, mounted five inches apart on a wood frame, served as the discriminanda for the conditioned fear. The light followed by the shock was placed on the subject's left and had the letter "S" painted on in black. The frame was placed at the foot of the couch, about two feet above eye level.

The apparatus was situated in two adjoining rooms. The audio-oscillator and shocker were placed on a table at the head of the subject's couch and outside his immediate range of vision. The dermohmeter was in the adjoining room which was separated by a wall and a small one-way window. Throughout the study two experimenters (Robert Abelson and Arthur Platz) were used; one in the testing room with the subject, the other monitoring the GSR recording in order to mark the precise time of CS presentation. In general, the experimenters alternated roles after each subject.

During the testing, the general illumination of the test room was kept at a low level by means of an adjustable rheostat. A four step testing procedure was followed for each group.

1. Fear Conditioning

A partial reinforcement training procedure was followed. The following instructions were given to the subjects: "Whenever the light on your left - the one with the S for shock - goes on, you may receive a shock. When the light on your right goes on, you will never be shocked."

The duration of the CS (light) was .5 seconds. The CS-UCS interval was randomly varied from 0 to 5 seconds after light termination to prevent the subject from "setting" himself for the shock and to increase uncertainty during conditioning. The intensity of the shock was determined individually for each subject on the basis of his tolerance during several pre-trials. To some extent both the duration and intensity of shock were varied (within narrow limits) again, to give greater uncertainty to the test situation and thus help prevent rapid extinction. Some attempt was made to counteract adeptation effects to the UCS by gradually increasing its intensity during test trials, but not too successfully because of the high initial level selected and traumatic responses from the subjects. The voltage between subjects varied from 100 to 200 volts at 120 cps.

Twenty-nine conditioning trials were given: fourteen with the no shock light, twelve reinforced trials to the shock light and three non-reinforced trials. A 100% reinforcement schedule to the positive CS was followed during the initial trials, changing gradually to a partial

reinforcement schedule approximately matching the ratio of reinforced to non-reinforced trials to be used during the test for stimulus generalization. Throughout the fear conditioning no response was required of the subject beyond that of watching the two stimulus lights.

2. Auditory Discrimination Training

A modification of a procedure employed by Brown, Clarke, and Stein (1958) for studying generalization of verbal responses was used during training and the subsequent tests for stimulus generalization. Subjects in both training drive groups were trained on the middle and extreme stimuli of a seven point sound intensity scale to respond "hit" to the middle stimulus (S4) and "miss" to the end stimuli (S1 and S7). The seven stimuli making up the scale (42.50, 43.50, 44.25, 45.00, 46.50, 47.50, and 50.00 decibels: training stimuli underlined) were selected on the basis of pre-testing to give a roughly symmetrical gradient with the peak and median falling at S4 under the train and test low drive condition. A - + - discrimination procedure described below was utilized to increase the slope of the "hit" generalization curve, thereby augmenting the response change per unit change in stimulus intensity.

After removing the shock electrodes, the train low group received the following instructions: "Now in this part I want you to learn to tell the difference between three different sounds which are nearly alike, but differ in loudness. There will be just three different sounds: one of them will always be called a "hit" whenever it is presented, and the other two will be called "miss" when you hear them. Do you understand? What you have to do is to learn which

sound is the "hit" and which two are "misses."

"During this part of the experiment you will see the right or no shock light come on, which means that you will never be shocked. Then, about a second later you will hear the sound. After you make your guess as to whether it is a hit or miss, I will tell you whether you are right or not."

For the train high group the shock electrodes were left in place and the following sentences substituted in paragraph 2 of the instructions: "During this part of the experiment you will see the left or shock light come on, which means that you may be shocked or may hear a sound about one second after the light. When the shock light comes on, you will never know whether you are going to be shocked or hear the sound..."

Each training stimulus was presented twice with the experimenter announcing before presentation: "This sound will always be a hit (or miss)." Thirty nine training trials were then given to each subject, fifteen to the middle stimulus, and twelve each to the two end stimuli.

The stimuli were presented in random order at 15 second intervals. The procedure consisted of presenting the shock or no shock light (.5 second duration) followed one second after termination by a sound or shock of one second duration. After S responded, E informed him whether his response was correct or not. In addition to the regular training trials, the train high group received an additional twenty interspersed shock reinforcement trials during discrimination training.

3. Reconditioning

Each group was given an additional nine fear reconditioning trials following the partial reinforcement procedure described above.

4. Test for Stimulus Generalization

Before testing for generalization, the subjects of both groups were given the following instructions: "Now this time it will be a little different. You will see the warning light come on, and then hear the sound. This time when you tell me whether it is a hit or miss I won't be able to tell you whether you are correct or not."

"Also, I want you to watch the warning light. If the right light comes on, this means that you will hear the sound and will not be shocked. However, if the shock light comes on, this means that you may hear the sound or you may be shocked. In other words, when the shock light comes on, you won't know whether to expect the sound or the shock."

Twenty-one trials, three at each of the seven stimulus points, were given with the shock light preceding the sound (high drive condition) and twenty-one with the no shock light (low drive condition) preceding. An additional eighteen reinforcement trials were given to the shock light. Trials for each stimulus point and under the two drive conditions were randomized within successive blocks of twenty trials which consisted of seven shock light trials, seven no shock light trials, and six reinforcement trials to the shock light. Four sets of orderings were used with five subjects in each training group being tested with each set. During the test subjects were given no

information as to the correctness of their responses, nor told that testing would be on seven points rather than just the three used during training.

Scoring:

1. Generalization Curves

Generalization curves for the "hit" response were determined by simply counting its occurrence at each stimulus. The analysis of the generalization data is based on the raw frequency scores for each subject. In order to make the data comparable to other studies the raw frequency scores under the four test conditions have been converted into probability scores. The graphs presented are all group curves and represent the percent or probability of response "hit" for each stimulus under the different experimental conditions.

2. Unit of Measurement for the Galvanic Skin Response

There is considerable difference of opinion concerning the appropriate unit of measurement to use in the analysis of GSR recordings (J. Lacey, 1956; Woodworth and Schlosberg, 1954). Resistance, scored in units of ohm change, is now not generally used when comparisons must be made between individuals. The reasons for converting the resistance score are two-fold: (1) statistical, in order to change the original distribution such that it fits the normality and homogeneity of variance assumptions necessary for parametric tests; and (2) in order to factor out the correlation between base resistance level and the magnitude of resistance change which makes comparisons between

subjects partially spurious. O. Lacey and Spiegel (1949), in a study of eight units of GSR measurement, found that change in conductance gave the lowest correlation between response amplitude and initial resistance, and also satisfied the requirements of normality of distribution. This measure seems generally acceptable (Woodworth and Schlosberg, 1954) and has the additional advantage of having been used in a series of studies as the measure of drive strength associated with an emotional response (Runquist and Spence, 1959; Runquist and Ross, 1959). Consequently, when the GSR is to be subjected to statistical analysis, the unit of measurement will be change in conductance.

The GSR for the test trials was scored blind. The score was the difference between the conductance level at CS onset and the maximum point of deflection within the five second period following CS onset. Conductance is measured in units of micromhos and is defined as the reciprocal of resistance times 10 to the power of 6 ($C=1/R \times 10^6$).

Plan of Analysis

The analysis of the data will be discussed in three sections. The first section will be concerned with evaluating the effectiveness of the training and test drive manipulations by means of the GSR shown during high and low fear trials. The second section will deal with changes in stimulus generalization resulting from the drive manipulations. Differences in the medians of the generalization curves will be evaluated by analysis of variance attributable to training drive and test drive. Some consideration will be addressed

to the question of whether the position of the medians is more closely related to absolute test drive level or to changes in drive from training to test. In the final section, the relation between GSR and verbal response will be examined. The GSR will be used as an index of drive strength to test the hypothesis that the probability of response "hit" increases with drive level for the weaker stimuli but decreases for the stronger ones. The analysis will be focused on the problem of whether changes in the probabilities of the alternative responses to specific stimuli in a discrimination task are related to the interaction of drive and habit strength as postulated by Hull and Estes, or to the scale value of the test stimulus relative to the positive training stimulus as postulated by the drive-stimulus interaction hypothesis.

## RESULTS

### Effectiveness of the Drive Manipulation

The mean change in conductance and the significance tests for the drive manipulation during training and testing are presented in Table 1. The mean GSR during the training trials under low drive as compared to the training trials under high drive is significantly different beyond the .05 level of confidence ($t=2.35$ with 38 degrees of freedom). For the group trained under low drive, the GSR for the low drive as compared to the high drive test trials is significantly different beyond the .001 level of confidence ($t=5.93$ with 19 degrees of freedom); for the group trained under high drive the difference in GSR during test trials for the two drive conditions also exceeds the .001 significance level ($t=4.18$ with 19 degrees of freedom). The GSR differences indicate that the degree of drive arousal elicited by the shock light was reliably greater than that elicited by the non-shcok light for each training group. Within a training group the GSR analysis validates the use of the shock and non-shock lights as the criterion, respectively, of the high and low drive trials during discrimination training and the subsequent test for stimulus generalization.

Table 1

Mean Change in the GSR Associated with High and Low Drive Training and Test Trials*

| | Training | Test High | Test Low |
|---|---|---|---|
| Train Low | .196 | .575 | .161 |
| Train High | .485 | .323 | .035 |

*Unit: Change in conductance in micromhos.

Table 1 - Cont'd.

**Tests for Significance**

| | | | |
|---|---|---|---|
| Training: High drive vs Low drive: | t=2.35 | p < .05 | 38df |
| Train Low: Test High vs Test Low: | t=5.93 | p <.001 | 19df |
| Train High: Test High vs Test Low: | t=4.18 | p <.001 | 19df |

**The Effect of Change in Drive on Stimulus Generalization**

A. Differences in the Medians of the Generalization Curves Related to Training and Test Drive Levels

In a previous section the hypothesis that effective or perceived stimulus intensity is a joint function of momentary drive level and physical stimulus intensity was presented and two predictions concerning the effects of changes in drive level on stimulus generalization were made: (1) increasing drive from training to test trials will displace the generalization gradient toward the weaker stimulus intensities, and (2) decreasing drive from training to test will produce a corresponding displacement toward the stronger stimulus intensities. The experimental test of these predictions is shown in the accompanying graphs. The effects of increasing drive on stimulus generalization are shown in Figure 2 and of decreasing drive in Figure 3. The analysis of differences in the medians of the generalization curves related to the drive level during training and testing is presented in Table 2.

Examination of Figures 2 and 3 indicates the predicted displacement of the generalization curves resulting from changes in drive level. Since increasing drive after low drive training produces a shift opposite to that produced by decreasing drive after high drive training, part of the variance of the medians should be attributable to the training drive.

FIGURE 2: TRAIN LOW GROUP

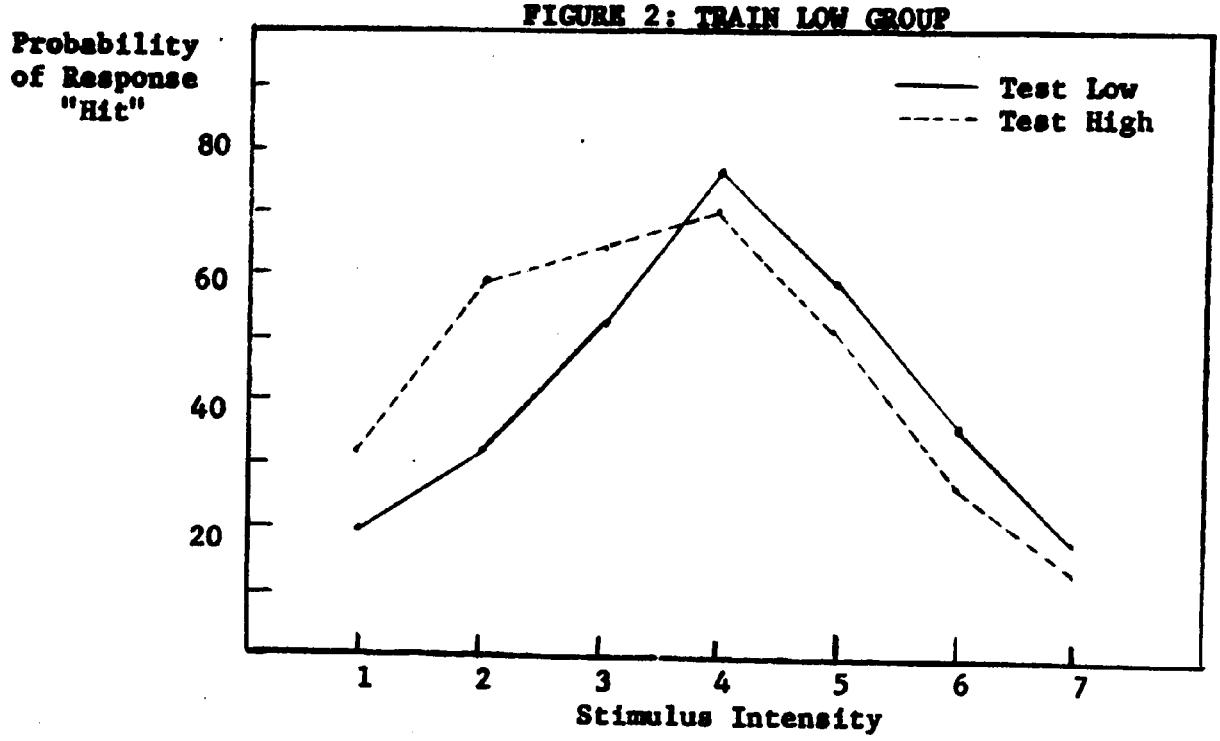



FIGURE 3: TRAIN HIGH GROUP

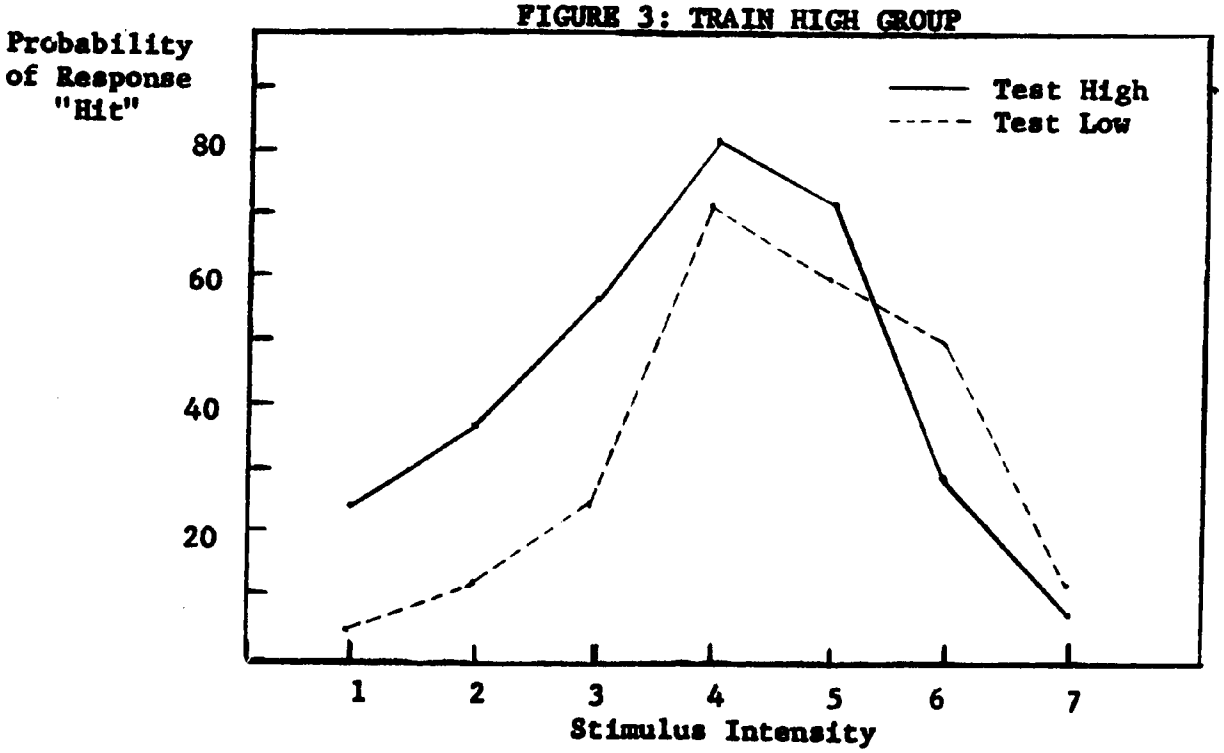



Figure 2 and 3: Generalization Curves of Response "Hit" Following High and Low Drive Training.

Table 2

Analysis of Variance of the Medians of the Generalization Curves Obtained under the Different Drive Conditions

| Source | df | SS | MS | F |
|---|---|---|---|---|
| Between Ss | 39 | | | |
| Training Drive | 1 | 37,984 | 37,984 | 5.07* |
| Error (b) | 38 | 284,496 | 7,487 | |
| Within Ss | 40 | 214,291 | | |
| Test Drive | 1 | 105,351 | 105,351 | 36.85** |
| Interaction | 1 | 300 | 300 | .10 |
| Error (w) | 38 | 108,640 | 2,859 | |

* p .05
** p .001

t Tests

1. Training Drives: high/high vs low/low — $t = .34$ p - ns
2. Train High: Test High vs Test Low — $t = 4.02$ $p < .001$
3. Train Low: Test High vs Test Low — $t = 4.56$ $p < .001$

Table 3

Medians of the Generalization Curves Obtained under the Different Drive Conditions*

| Training Drive | Test Drive: Low | Test Drive: High | Difference |
|---|---|---|---|
| Train Low | 45.45 | 44.68 | .77 |
| Train High | 45.84 | 45.16 | .68 |
| Train Low | | | |
| a. Large difference in test drives | 45.33 | 44.48 | .85 |
| b. Small difference in test drives | 45.57 | 44.89 | .68 |
| Train High | | | |
| a. Large difference in test drives | 45.98 | 45.12 | .86 |
| b. Small difference in test drives | 45.71 | 45.19 | .52 |

* Score: Mean of the distribution of medians under each test condition.

This effect is significant beyond the .05 level (F=5.07 with 1 and 38 df). To some extent this effect is attenuated because of differences in the training curves since the mean of the distribution of medians obtained under the train and test low condition is slightly greater than that obtained under the train and test high condition (45.45 db and 45.16 db. The difference is not statistically significant). The predicted effect of the test drive discussed earlier is significant beyond the .001 level (F=36.85 with 1 and 38 df). An evaluation of the effects of change in drive by t tests following the analysis of variance indicates that the mean of the distribution of medians obtained under the high/low condition was significantly greater than that obtained under the high/high condition ($t=4.02$, $p < .001$). The mean for the training curve was 45.16 db compared to 45.84 for the experimental curve, indicating an average displacement of .68 db (See Table 3). For the train low group the mean of the medians under the low/low condition was 45.45 db and 44.68 db for the low/high test condition. The displacement of .77 db is significant beyond the .001 level ($t=4.56$). It might be noted that while the difference in the training curves attenuates the results when differences due to the training drive are evaluated, it accentuates the difference when the test drive effect is tested.

The use of the GSR as a measure of drive during the test trials makes possible a further test of the drive-stimulus interaction hypothesis. If effective stimulus intensity is partially dependent upon the drive level during stimulus presentation, then the difference in the medians of the two generalization curves should be related to the difference between the high and low test drive levels. Accordingly,

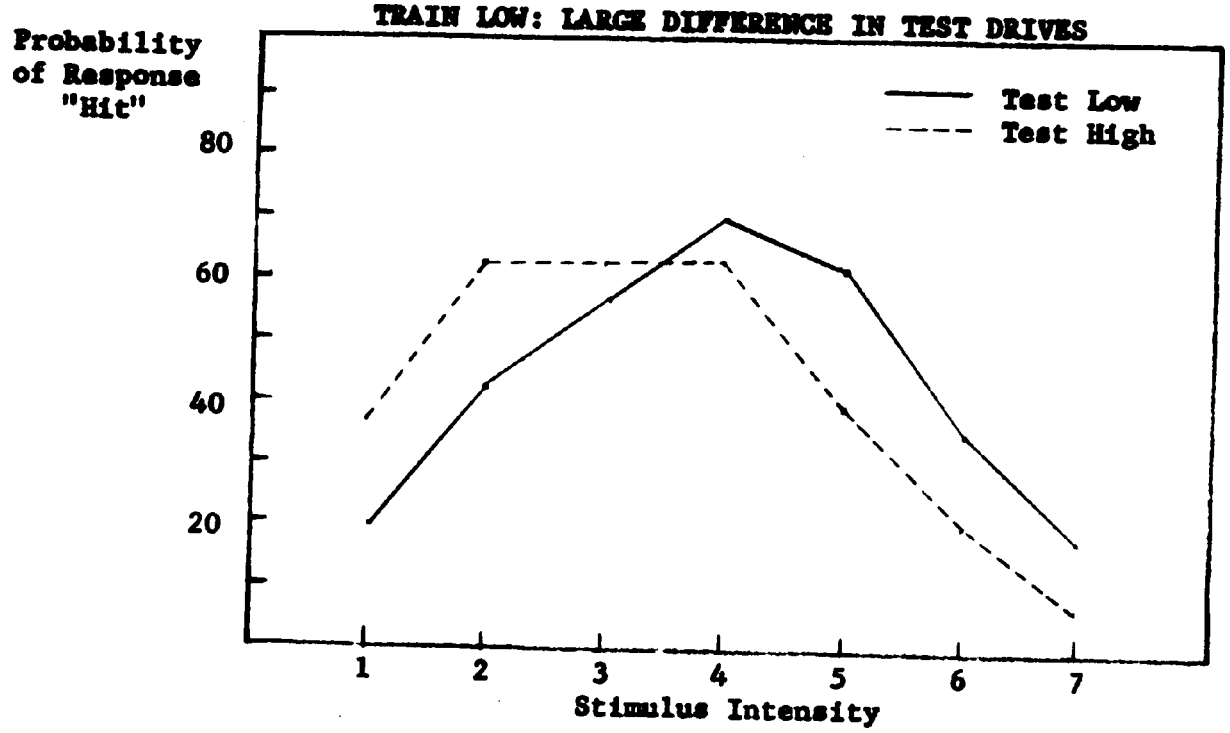
Ss in both training groups were classified into two categories reflecting the degree to which the fear response was differentially conditioned to the shock and non-shock lights. The difference in drive score was obtained for each subject by subtracting the mean GSR during low drive test trials from that obtained during the high drive trials. The curves for Ss in each training group showing a large and those showing a small difference between the two test drives are shown in Figures 4 and 5, and the means for each condition in Table 3. Ss from the train high group showing a large difference between the two test drives showed a 65% greater displacement of the test generalization curve than did Ss showing a small GSR difference. In the train low group, a 25% greater displacement effect is obtained. This effect, however, does not approach significance (Table 4. F=1.62 with 1 and 38 df).

Although these results are in the predicted direction, they do not allow a crucial test of the hypothesis since the classification of Ss rests on the untestable and probably incorrect assumption (untestable, at least, with the present data) that the difference between the two test drive levels is related to the difference between the two GSR scores irrespective of their magnitude. The necessity of this or similar assumptions about the interpretation of GSR differences prevents analyses based on between subject comparisons from being critical to the theory, although the results may be highly suggestive.

Table 4

Analysis of Variance of the Displacement of the Generalization Curves as a Function of the Difference Between the High and Low Test Drive Levels

| Source | df | SS | MS | F |
|---|---|---|---|---|
| Difference in Test Drives | 1 | 8,910 | 8,810 | 1.62 ns |
| Error | 38 | 208,986 | 5,500 | |



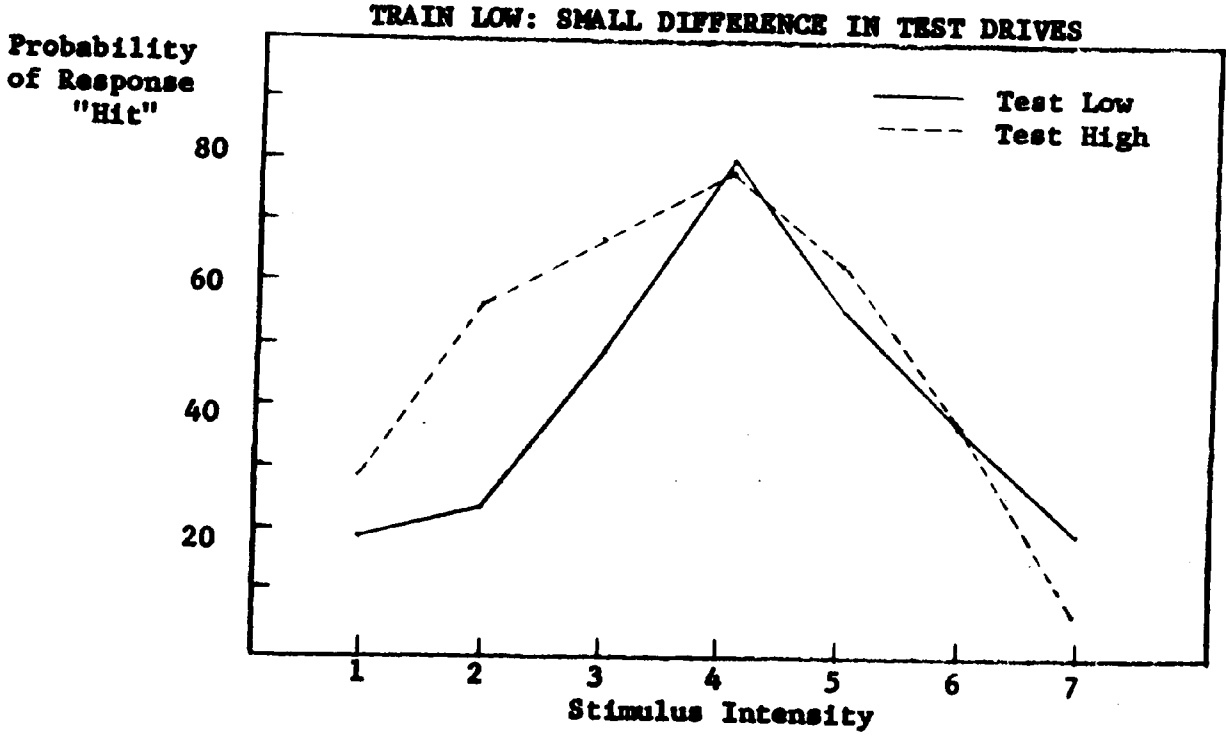
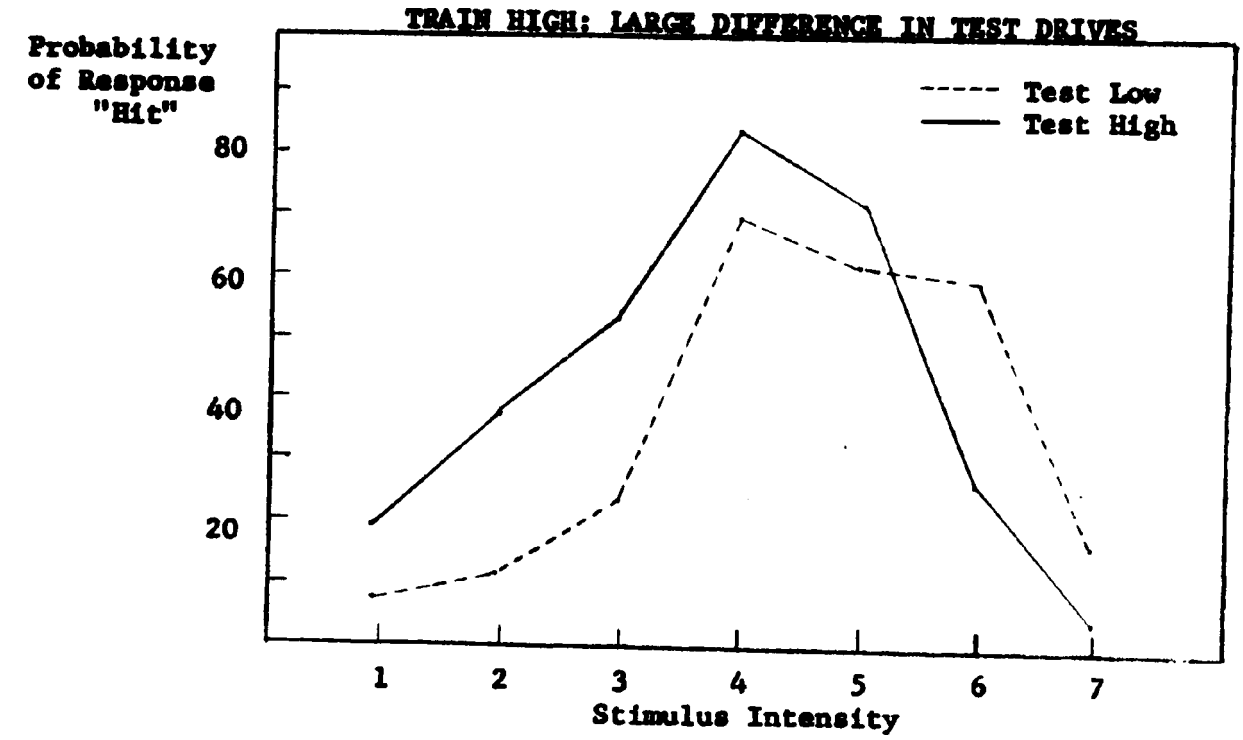




Figure 4: Generalization Curves for Response "hit" for Train Low Ss showing Large and Small Differences in Test Drives.



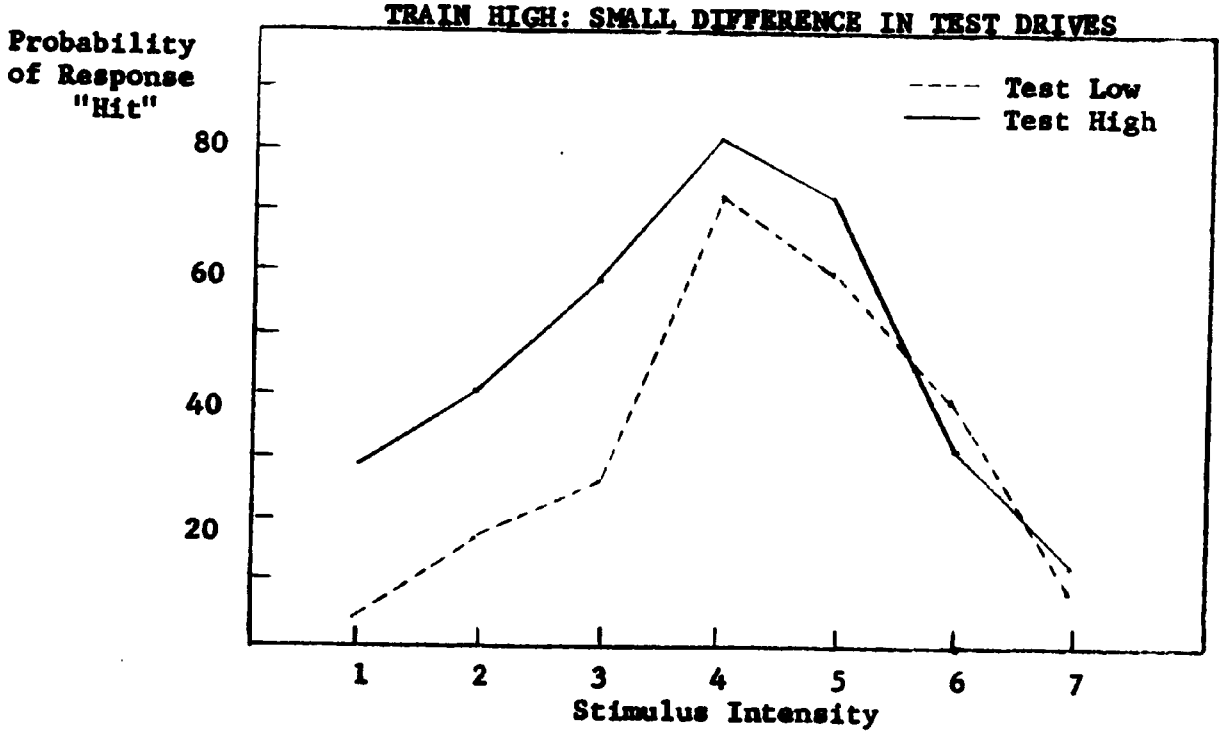




Figure 5: Generalization Curves for Response "Hit" for Train High Ss showing Large and Small Differences in Test Drives.

B. Relation of Change in Drive and Test Drive to Stimulus Generalization

In testing the effects of change in drive on stimulus generalization Dorfman (1960) failed to find the predicted effect attributable to the training drive, but did find a significant test drive effect. Subsequentanalysis showed a significant difference between the medians of the high/high and low/low curves. By assuming that drive alters discriminability (i.e., the drive produced increment in effective stimulus intensity is not constant for all physical stimulus intensities so that a change in drive also differentially alters the inter-stimulus differences) Dorfman was able to handle the difference between the training curves within the drive-stimulus interaction framework. Although this may be intepreted as a stimulus effect of drive, the difference between the medians of the two training curves suggests that the critical factor producing the differences in the generalization curves may be simply the drive level during the test trials rather than the change in drive from training to test as originally implied by the drive-stimulus interaction hypothesis.

Although both the original hypothesis and its proposed modification postulate a stimulus effect of drive, the behavioral consequences are quite different. Following the original drive-stimulus interaction hypothesis, drives are assumed to change the scale value of stimuli. However, this change in effective stimulus intensity is assumed to be constant across physical intensities so that the effect is observable only when drive is changed from training to test. The assumption of a non-additive effect of drive such that the effective intensity of stimuli is not changed equally means that the distances between effective

stimulus intensities are also changed. This change in stimulus distances indicates a change in discriminability between stimuli and is reflected in differences in the symmetry of generalization curves obtained under different test drive levels independent of the training drive level (Dorfman, 1960).

Part of the difficulty in testing between these alternative hypotheses stems from the experimental design used both in Dorfman's study and in the present experiment since the design allows drive level to be scored only in terms of the two categories of the drive manipulation, high or low. However, since the GSR readings are available for both the training and test trials, both the absolute and relative test drives may be assessed in terms of a continuously distributed measure of physiological activation.

In this analysis, change of drive or relative test drive is defined as the mean GSR (mean change in conductance following presentation of the shock or non-shock light) on the training trials minus the mean GSR on the test trials. If the drive-stimulus interaction hypotheses is correct, this measure of change in drive should correlate highly with the medians of the generalization curves. The measure of absolute test drive is simply the mean change in conductance during the test trials. If the level of drive during the test trials produces the displacement of the generalization gradient by spreading the stimulus points unequally, then this should be reflected in a high correlation between the GSR during testing and the median of the generalization curve. Since the measure of the relative test drive is a derived score based partly on the GSR during the test trials, it should also correlate highly with

absolute test drive. The rank order correlation is, in fact, .45. This lack of independence in the two drive scores means that both may be correlated with the median of the generalization curves. Although this contamination cannot be controlled experimentally, it may be statistically controlled by the use of partial correlations.

The rank order correlations based on the 80 generalization curves (40 subjects tested under two drive conditions) are presented in Table 5. The observed drive level during test trials shows a rank order correlation of -.32 with the median of the test generalization curve ($t=2.84$; $p < .01$); change in drive correlated -.45 with the median ($t=4.00$; $p < .001$). However, when the effect of change in drive is partialled out, the correlation between absolute test drive and the median falls to -.15 ($t=1.32$), which is not statistically significant. Partialling out covariation due to the absolute test drive reduces the correlation between change in drive and the median to -.37 which is significant beyond the .002 level ($t=3.25$).

The partial correlations indicate that change in drive from training to test is related to the median of the generalization curve obtained during testing. There is, however, no evidence for a relationship between test drive level and stimulus generalization when the effect due to change in drive is statistically controlled. This is consistent with the failure to find a significant difference between the high/high and low/low curves reported in Section A. These data, then, do not support the hypothesis that the increment in effective stimulus intensity produced by a given drive varies as a function of the intensity of the physical stimulus. However, the degree of correlation between change in

drive and the median does suggest that the drive produced increment in effective stimulus intensity increases as a function of the magnitude of the difference between the training and testing drives.

Table 5

Correlations between Change in Drive, Absolute Test Drive and the Median of the Generalization Curve

| | Rho | t |
|---|---|---|
| **Zero Order Correlations** | | |
| Relative test drive and Median | -.45 | 4.00 *** |
| Absolute test drive and Median | -.32 | 2.84 * |
| Absolute and Relative test drives | +.45 | 4.00 *** |
| **Partial Correlations** | | |
| Relative test drive and Median | -.37 | 3.25 ** |
| Absolute test drive and Median | -.15 | 1.32 |

* $p < .01$
** $p < .002$
*** $p < .001$

C. Flatness in the Gradient of Stimulus Generalization Related to the Drive Manipulation

The present study investigated the predicted displacement of the stimulus generalization gradient derived from the hypothesis that drive increases effective stimulus intensity. This effect may be contrasted with those predicted from the behavioral theories of Hull-Spence (1943, 1956) and Estes (1958) in which it is assumed that drives have only response effects. In these two theories the effect of drive depends upon the strength of the association between the stimulus and the response, although the theories lead to opposite predictions. Within the Hull-Spence model drive increases the difference between the

reaction potentials of two incompatible habits. Thus, in accordance with the energizing effect of drive (the DxH law), Di(Ha - Hb)>Dj(Ha-Hb), where Di>Dj. In the present context this leads to the prediction that the high/high curve will have a steeper slope than the low/low curve, and that increasing drive from training to test (low/high) will result in a steeper gradient than decreasing drive (high/low).

In Estes' (1958) stimulus sampling model the effect of irrelevant drive stimuli which are equally associated with the two responses (probability of either response occurring to the drive stimuli is .5) will also depend upon the response probability associated with a given stimulus set. If this probability is greater than .5, the addition of irrelevant drive stimuli will reduce the response probability; if less than .5, the response probability will be increased. Consequently, one might expect the high/high curve to be flatter than the low/low because of the presence of irrelevant or non-differentially conditioned drive stimuli; and the high/low curve steeper than the high/high. (These predictions are based upon two assumptions: (1) associative strength to irrelevant stimuli does not become extinguished over trials; and (2) previously unpresented stimuli are attached to and equally likely to elicit either response). If it may be assumed that the distribution of the reaction potentials for response "hit" about the positive training stimulus is perfectly symmetrical, neither the Hull-Spence nor the Estes theory predicts a displacement of the generalization curve.

As an index of flatness and slope, variances for the individual curves were computed and analyzed in terms of differences related to

training drive, test drive, and number of errors made during auditory discrimination training (Table 6). Not unexpectedly, number of errors during discrimination learning is significantly related to the flatness

Table 6

Analysis of Variance of Flatness of the Generalization Curves[1]

| Source | df | MS | F |
|---|---|---|---|
| Between Ss | 39 | | |
| Training Drive (B) | 1 | 41,953 | 4.74 * |
| Training Errors (C) | 1 | 78,751 | 8.89 ** |
| Interaction (BC) | 1 | 48,709 | 5.50 * |
| Error (b) | 36 | 8,860 | |
| Within Ss | 40 | | |
| Test Drive (A) | 1 | 15 | .00 |
| AxB Interaction | 1 | 3,354 | .56 |
| AxC Interaction | 1 | 259 | .04 |
| ABC Interaction | 1 | 1,920 | .32 |
| Error (w) | 36 | 5,951 | |

[1]Score: Variance of the generalization curve.

* $p < .05$
** $p < .01$

of the subsequent generalization curves ($F=8.89$; $p < .01$ with 1 and 36 df). Training under high drive produced subsequently steeper generalization gradients than training under low drive ($F=4.74$; $p < .05$ with 1 and 36 df); drive level during testing was not significantly related to degree of flatness. The comparisons suggested above in connection with the theories of Hull-Spence and Estes were evaluated by separate "t tests." None of the expected differences (high/high vs low/low; low/high vs high/low; and high/low vs high/high) were statistically significant. These data thus provide no clear evidence that either the energizing effect of drive or the associative strength acquired by drive stimuli affects

stimulus generalization subsequent to - + - discrimination training. Neither increase nor decrease in drive produced significant changes in the variances of the response curves (t=.57 and .40 respectively).

## SUMMARY AND DISCUSSION

The experiment reported in this section was designed to test Dorfman's theory that effective or perceived stimulus intensity is a function of drive level: S'=f(D,S) (Dorfman, 1960, 1961). An implication of the theory suggested by Zajonc that changing drive level from training to test would shift the gradients of stimulus generalization was derived and confirmed in Section A. Section B was concerned with a problem of interpretation raised by previous findings of a significant test drive effect in the absence of a significant effect attributable to either the training drive or the interaction between training and test drive levels (Dorfman, 1961). In the latter study, the high drive curves were displaced toward the smaller physical stimulus intensities regardless of whether or not the drive level was changed from training to test. Similarly, the low/low curve was displaced slightly toward the larger physical stimulus intensities. By using the amplitude of the GSR as an index of drive arousal, the present data demonstrated a significant relation between change in drive from training to test and the median of the generalization curve, but no relation between the drive level during test trials and the median of the curve when the effects of change in drive were statistically controlled. In Section A no difference was found between the two training curve, high/high and low/low. Thus, both the definition of drive in terms of an antecedent operation (a discriminated fear response differentially conditioned to

a positive and negative CS) and in terms of a concomitant physiological response generally assumed to be an index of level of arousal (change in skin conductance as a measure of $r_e$) are consistent in showing that changes in drive level from training to test produce predictable changes in stimulus generalization which are consonant with the hypothesis that increasing drive also increases effective stimulus intensity.

These data are less easily handled within the Hull-Spence theory in which it is assumed that drives have only response effects. In this model increase in drive may affect response measures in two ways: (1) by increasing the excitatory reaction potential of a given habit: $E=DxH$, and (2) by changing the drive-stimulus component of sHr. In the present experiment in which two responses, "hit" and "miss", are associated to a given stimulus, it may be assumed that the net reaction potential of either response is given by the equation $E_h - E_m = D(H_h - H_m)$. The relationship between response probability and $E_h - E_l$ is determined by the degree to which the distribution of the momentary reaction potentials are above threshold; when the distributions are chiefly above threshold, the relation is an increasing monotonic function; when largely below threshold, a monotonically decreasing one (Spence, 1956, 1958).

Since an assessment of the distribution of reaction potentials is not possible with the present data, the effect of change in drive on response probability is not clearly specifiable. However, given the drive produced changes in response probability illustrated in the displacement of the generalization curves, it is possible to infer what characteristics the distributions of the two reaction potentials must

have in order to account for this displacement. In the first case, for those auditory stimuli at which the probability of response "hit" is greater than that of "miss" under the train and test low drive condition, the displacement of the curves produced by increasing drive may be handled by assuming that the distribution of the larger reaction potential ($E_{hit}$) was largely above threshold for the stimulus values at which Pr(hit) increased, but largely below threshold at those points where it decreased. For those stimulus intensities where the probability of response "miss" is greater than response "hit", the effect of increase in drive may be accounted for by assuming that the distribution of the reaction potential for response "miss" is largely above threshold at those points where the Pr(miss) increased, but largely below threshold where it decreased. In a similar fashion, the displacement of the generalization curves produced by a reduction in drive level may also be handled. Two things may be noted with this argument. First, the distribution of the probability of response "hit" about the central training stimulus is nearly symmetrical for both training curves (low/low and high/high. See Figures 2 and 3). Thus, the most reasonable assumption about the distribution of reaction potentials would seem to be that they too are symmetrical. However, in order for the Hull-Spence theory to handle the data, it must be assumed that at S3 under low drive, where Pr(hit)>.5, the distribution of $E_{hit}$ is largely above threshold, but that at S5, where Pr(hit) is also greater than .5, the distribution is largely below threshold. Although these assumptions do account for the decrease in Pr(hit) to S5, and its increase to S3 when drive level is increased, the distribution of the response probabilities in the training curves provides no support for such specific

assumptions. This same argument may be extended to the analysis of the effects of change in drive on the right and left wings of the stimulus generalization gradients. Again, the number of training trials is the same for stimuli 1 and 7 and the training and test drive levels are identical for both wings. Under these conditions the Hull-Spence model does not easily handle the differential effect of change in drive on the two wings, where increase in drive depresses the left wing but elevates the right (Figure 2), and decrease in drive elevates the right wing but depresses the left (Figure 3).

A second point may be raised in the case where $E_H = E_M$ and Pr(Hit) is consequently .5. Since $E_H - E_M = D(H_H - H_M) = 0$, a change in drive level (D) should not produce a corresponding change in response probability. However, inspection of Figures 2 and 3 indicates that at the interpolated stimulus intensities of the training curves where Pr(hit)=.5, the response probability was altered by the change in drive, and the direction of this effect under a given change in drive was dependent upon whether the stimulus was more or less intense than the positive training stimulus, S4.

The failure of the Hull-Spence model to handle the change in response probability for those stimuli where $E_H = E_M$, and the necessity for very specific <u>ad hoc</u> assumptions to account for the differential changes in the Pr(hit) at S3 and S5 indicates the superiority of the hypothesis of a stimulus effect of drive on two counts; (1) firstly, the drive-stimulus interaction hypothesis leads to specific predictions of drive effects on response probability which cannot be made in terms of the Hull-Spence theory since the specific relations between response

threshold and the distributions of excitatory reaction potentials are not known. And (2) the hypothesis of a stimulus effect of drive handles the observed changes in stimulus generalization with the fewest assumptions and more parsimoniously than interpretations in terms of previous theories which assume only response effects of drive.

## The Relation Between GSR Changes and Response Probability Following Discrimination Training

In the present section the antecedent operation defining drive, the presentation of the positive or negative conditioned stimulus for fear which preceded each trial, will be disregarded and drive defined solely in terms of the amplitude of the galvanic skin response occurring during the test trials. It was argued earlier that $S'=f(r_e,S)$; that is, effective stimulus intensity is a function of the momentary emotional state of the subject. If this is the case, the response probability associated with a given auditory stimulus should show certain predictable relations to the amplitude of the GSR elicited by the positive or negative CS for the fear response. The nature of this functional relationship will be examined below.

### A. The Relation Between GSR and Verbal Response as a Function of Stimulus Intensity.*

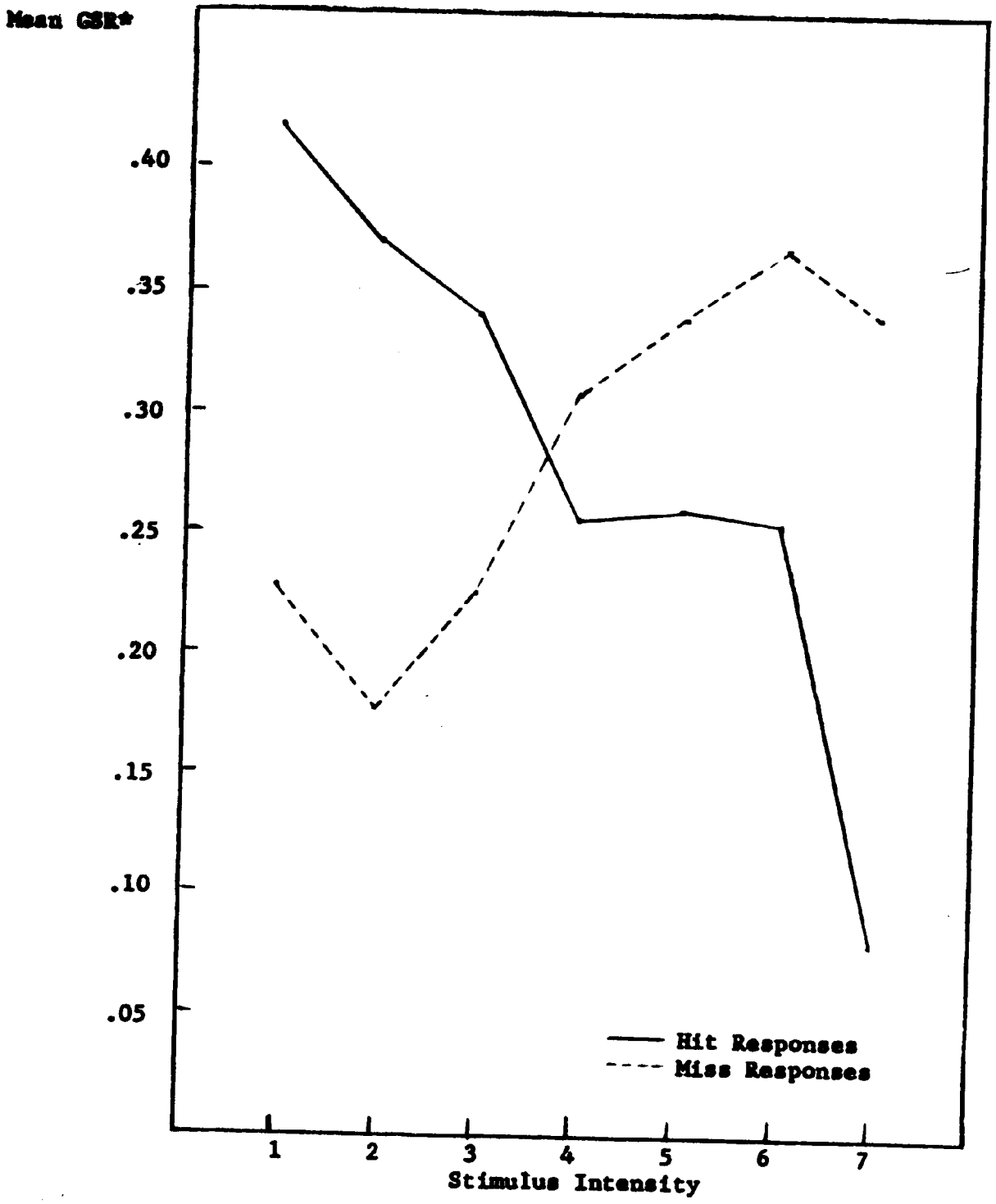
According to the hypothesis that $S'=f(r_e,S)$ the probability of the weaker physical stimulus intensities, S1, S2, and S3, eliciting response "hit" should increase as drive increases, whereas the probability of response "hit" to the stronger stimuli, S5, S6, and S7, should decrease with increasing drive. This leads to the prediction that if we analyze the GSR accompanying "hit" and "miss" responses, the mean GSR accompanying "hit" responses should be greater than that of "miss"

responses for the weaker sound intensities. Conversely, for the stronger stimuli the mean GSR associated with the "hit" responses should be less than that associated with the "miss" responses. That is, the subject's "hit" responses to the weaker stimuli should be accompanied by a higher drive level (larger GSR) indicating that effective stimulus intensity was increased, and the "hit" responses to the more intense stimuli by a lower drive level (smaller GSR) indicating that effective stimulus intensity for these points was relatively weaker than during training. The magnitude of the increment or decrement in effective stimulus intensity is assumed to increase monotonically with the degree of drive change. The magnitude of change in effective intensity necessary to produce a change in the verbal response will depend upon the intensity difference between the test stimulus and the positive training stimulus, S4.

Since stimulus S1 is more distant from stimulus S4 than is stimulus S2 or S3, the increase in drive must be greater for S1 to be called a "hit" than for either S2 or S3. Similarly, the mean GSR for stimulus S7, on those trials when it is called a "hit", should be less than that for stimuli S5 or S6. Consequently, the mean GSR associated with "hit" responses should decrease with stimulus intensity, and the mean GSR for

*The data in Section A are based on the forty subjects combined across all four testing conditions and categorized on the basis of the subject's verbal response to each test stimulus. Since individuals differed in the relative frequency with which they used the "hit" and "miss" responses and in the amount of shift which they showed, they are unequally weighted for specific stimuli. This lack of independence of scores rules out the possibility of a more powerful statistical analysis. However, it should be noted that this lack of independence is itself part of the experimental effect: i.e., subjects trained under low drive who showed a large mean GSR under the test high condition were also more apt to show a shift in the generalization curve during the high drive test trials than subjects showing a smaller mean GSR.

Figure 6




*Change in conductance in micromhos.

Mean GSR Accompanying "Hit" and "Miss" Responses

those trials when a "miss" response was given should increase, with the two curves crossing near the positive training stimulus, S4.

These data are presented in Figure 6. As predicted, the mean GSR accompanying "hit" responses tends to decrease as stimulus intensity increases; the rank order correlation between mean change in conductance on those trials when response "hit" was made and stimulus intensity is -.96 ($p < .05$). The comparable rank order correlation between stimulus intensity and mean GSR on trials where a "miss" response was given is .86 ($p < .05$). Also, as predicted, the two curves tend to become increasingly divergent as the distance from the positive training stimulus, S4, increases.

It is instructive to compare the relation between the GSR as a measure of drive level and changes in the verbal response which might be expected from the behavior theories of Hull-Spence and Estes. In the Hull-Spence* theory the energizing effect of drive increases the difference between the reaction potentials of competing habits: $D_i(H_h - H_m) > D_j(H_h - H_m)$, where $D_i > D_j$. Since Pr(hit) is greater than .5 for the middle stimuli, S3, S4, and S5, and less than .5 for the extreme stimuli, S1, S2, S6, and S7, one might expect that as the amplitude of the GSR increases, Pr(hit) would also increase for the middle stimuli but decrease for the end stimuli. If this were the case, response "hit" to the middle stimuli should be associated with a larger GSR than response "miss." For the extreme stimuli, since "miss" is the stronger response, response "miss" should be associated with the larger

*To simplify the argument, the effect of generalization along the drive-stimulus intensity dimension is not considered here. However, since its effect should not be dependent upon the intensity of the discriminanda, its operation cannot account for the relations shown in Figure 6.

GSR. The effect of drive within the Hull-Spence theory is dependent upon the relative habit strengths of competing responses. Since an equal number of training trials were given at S1 and S7, differences in habit strength cannot account for the observed relation between drive and the probability of the competing verbal responses shown in Figure 6 without special ad hoc assumptions about the thresholds of the momentary reaction potentials for stimuli S1 and S7.

In a stimulus sampling model such as that proposed by Estes (1956) drive is defined simply as a class of stimuli and is considered to have an associative function rather than an energizing function as emphasized in the Hull-Spence theory. Drive stimuli, like all stimuli, determine behavior only to the extent that they serve as conditioners for a learned response. Since the probability of a specific response on a given trial is proportionate to the number of relevant or conditioned stimuli divided by the total number of stimuli present, an increase in irrelevant or non-differentially conditioned drive stimuli should decrease the probability of the stronger response. Following discrimination training the probabilities of the two responses are defined as $p$ and $1 - p$ where:

$$p = \frac{\text{relevant stimuli}}{\text{total stimuli}} + (.5)\ \frac{\text{irrelevant stimuli}}{\text{total stimuli}} *$$

Consequently, for the middle stimuli, when drive level is high as defined by the magnitude of the GSR change, the dominant response "hit" should be less likely to occur; for the extreme stimuli, the frequency

---

* This equation assumes that new stimuli possess equal associative strength with each response. If irrelevant stimuli adapt out, or if new stimuli are neutral and do not have associative strength, their presence will not affect the relative probabilities of the competing responses. If this should be the case, drive would not be related to the probability of response "hit."

of the dominant response "miss" should decrease. The larger GSR's during presentation of S3, S4, and S5 should therefore be associated with the "miss" response; and for S1, S2, S6, and S7 with the "hit" response. This leads to a prediction in opposition to that of Hull and Spence: increase in drive lowers the response probability of the dominant habit by adding irrelevant or non-differentially conditioned stimuli.

The expected curves from the Hull-Spence and Estes' theories are markedly different from the obtained curves. If drives have stimulus effects as postulated by the drive-stimulus interaction hypothesis, the relationship between the probability of response "hit" or "miss" and changes in drive level will depend upon the intensity of the test stimulus, and the relationship will be reversed as one goes from test stimuli which are weaker than the positive training stimulus to ones which are stronger. The Hull-Spence and Estes' theories do not relate the effect of drive on behavior to stimulus intensity, but rather to the response probabilities of the alternative habits associated with a given stimulus intensity; when one moves from a stimulus where the probability of response "hit" is greater than .5 to one where it is less, the curves of the mean GSR for the two verbal responses should cross. And since a - + - discrimination procedure was used, the curves should cross both on the right and on the left of the positive training stimulus, S4. The obtained curves presented in Figure 6 are consistent with the drive-stimulus interaction hypothesis and clearly inconsistent with the Hull-Spence and Estes' predictions.

An alternative interpretation of this relationship between GSR and response probability may be suggested. One might argue that the amplitude of the galvanic skin response varies as a function of physical stimulus intensity. Then, for a given stimulus, if the audio-oscillator output fluctuated or if there were random variations in perceived intensity unrelated to the subject's drive level, these variations would be related both to the amplitude of the GSR and to the verbal response on that trial. If, for instance, stimulus S3 is perceived as slightly louder on a given trial, this would result in both a larger GSR and an increase in the probability of S responding "hit." Both response effects could be attributed to random fluctuations in perceived intensity which were independent of possible drive effects.

Since this interpretation of the observed relation between the GSR and the verbal responses rests on the assumption that an increase in physical stimulus intensity will elicit a correspondingly larger GSR, it may be directly tested within the range of sound intensities (42.50-50.00 db) used in the present experiment. The analysis of variance is presented in Table 7. The absence of a significant relation ($F<1.00$) between the intensity of the sound and the accompanying GSR makes this interpretation of the data unlikely.

Table 7

Analysis of Differences in GSR Amplitude Related to Sound Intensity

| Source | df | MS | F |
|---|---|---|---|
| Stimulus Intensity | 6 | 5,167 | .14 |
| Subjects | 39 | 184,594 | |
| Ss x Stimulus | 234 | 36,475 | |
| | 279 | | |

The interpretation consistent with the drive-stimulus interaction hypothesis is that the shock light elicits fear which is reflected both in a heightened GSR and an increase in effective sound intensity, as measured by the observed changes in response probability. The differences in the GSR are assumed to be caused by variations in the strength of the elicited fear response rather than by variations in the physical stimulus. Figure 6 may be interpreted to mean that on those trials when subjects showed most fear, the drive produced increment in stimulus intensity resulted in the weaker stimuli being perceived more often as S4 than when subjects showed little fear. Conversely, sounds louder than S4 were less likely to be mistaken for S4 when the subjects were more fearful than when they were less fearful. In this case, the increment in effective stimulus intensity resulted in the stimulus picking up more of the generalized habit strength of response "miss" associated with stimulus S7.

### B. The Probability of Response "Hit" as a Function of Changes in the Galvanic Skin Response

An alternative way at looking at the relation between the GSR and verbal response is to examine changes in the frequency of response "hit" as a function of changes in the GSR. The hypothesis that $S'=f(r_e, S)$ leads to the prediction that the probability of response "hit" to the weaker physical stimulus intensities should increase as the magnitude of the galvanic skin response increases, whereas the probability of response "hit" to the stronger physical stimulus intensities should decrease with increasingly larger GSR's. Within the drive-stimulus interaction framework the effect of change in drive following - + - discrimination training depends on whether a given test stimulus is

weaker or stronger than the positive training stimulus, and not on the relative habit strengths of the alternative responses associated with a given stimulus. This theory predicts opposite response effects of drive on the right as compared to the left wing of the generalization gradient. For the weaker stimuli, the drive produced increment in effective stimulus intensity decreases the distance between test stimulus and positive training stimulus, thus increasing the probability of response "hit." However, for stimuli greater than S4, the increment in effective stimulus intensity increases the stimulus distance which is reflected in a decreased probability of response "hit." Interpretations based on the relative strength of competing responses, such as Estes' and Spence's, should predict little or no difference related to stimulus intensity since the probability of response "hit" for the weaker stimuli is roughly comparable to that for the stronger stimuli under the training drive conditions.

To test this prediction each S's verbal responses to each stimulus were classified into either of two equal categories on the basis of whether the verbal response was accompanied by a large or small GSR. (Since this is a within subject comparison the use of the GSR shown during test trials will yield the same results as a relative drive score based on the difference between the training and test GSR.) For purpose of analysis the frequency of response "hit" was then combined for the three stimuli weaker than S4 (left wing of the generalization curve) and for the three stimuli stronger than S4 (right wing).

The results are presented in Figure 7 and the analysis of variance in Table 8. As predicted, the probability of response "hit" to the weaker stimuli is greater on those trials showing a larger GSR. For

**Table 8**

**Analysis of Variance in the Frequency of Response "Hit" as a Function of Stimulus Intensity and the Galvanic Skin Response.**

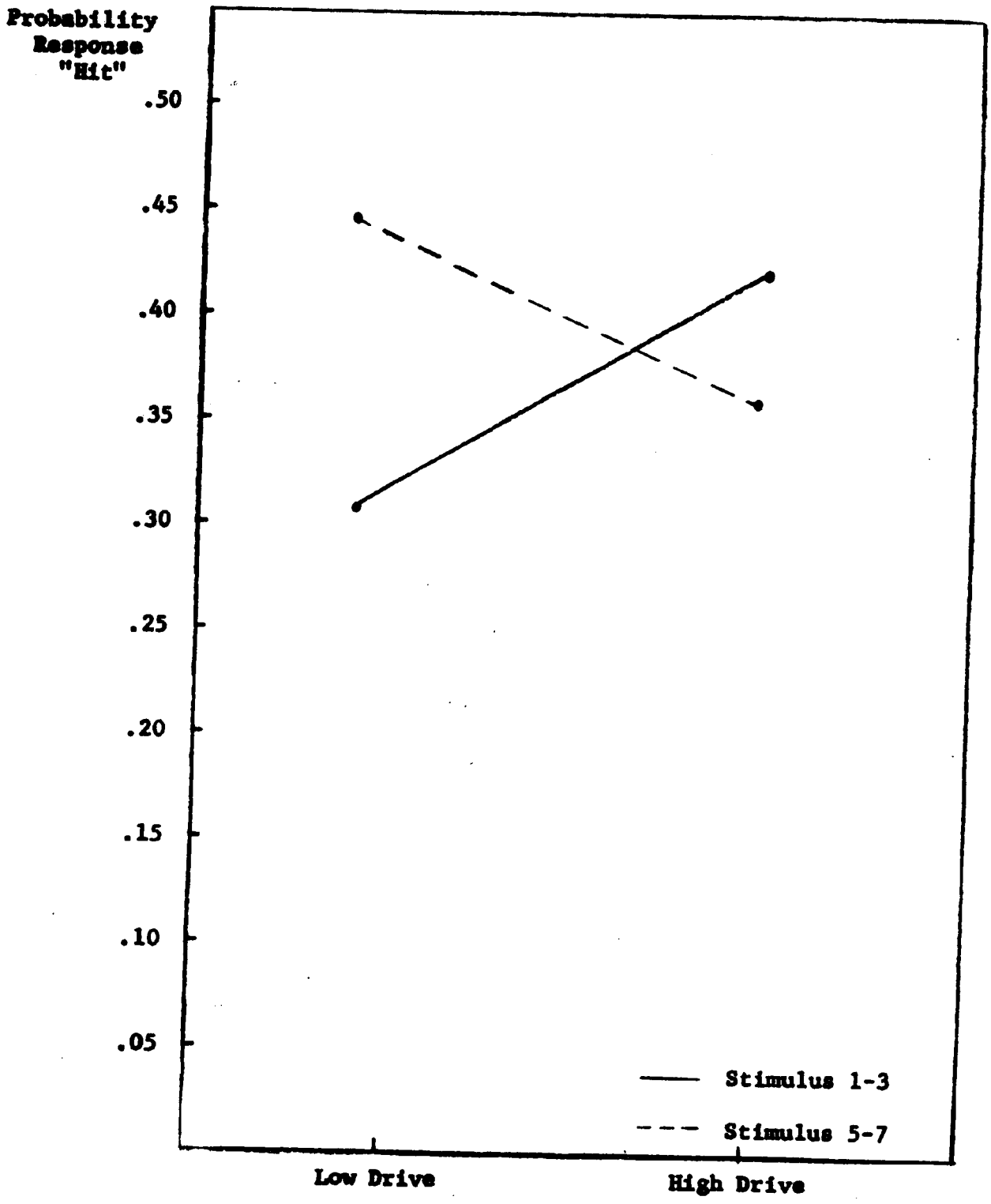
| Source | df | MS | F | P |
|---|---|---|---|---|
| Stimuli * | 1 | 62 | .09 | - |
| GSR ** | 1 | 568 | 2.99 | - |
| Subjects * | 39 | 261 | .39 | - |
| Stim x GSR | 1 | 1746 | 8.91 | .01 |
| Ss x Stim | 39 | 665 | 3.39 | .01 |
| Ss x GSR | 39 | 185 | .94 | - |
| Second Order Inter. | 39 | 196 | | |
| | 159 | | | |

*error: Ss x St interaction. (MS = 665)
**error: pooled Ss x GSR and 2nd order interaction. (MS = 190.5)

the stronger stimuli the probability of response "hit" decreases as a function of the amplitude of the GSR. This wing x GSR interaction is significant beyond the .01 level of confidence. (F=8.91 with 1 and 39df) The significant interaction supports the prediction derived from the drive-stimulus interaction hypothesis that the effect of increasing drive is determined by the relative intensity of the test stimulus and not by the associative strength of the response attached to the stimulus. Although the associative strength of response "hit" may be presumed to be roughly equivalent for both the weaker and stronger stimuli (p=.3514 and .3652 respectively), it should be noted that increasing drive has an opposite effect on the probability of its occurance to the weaker and stronger stimuli.

The absence of any effect attributable to the classification based on the GSR (F=2.99 with 1 and 78df) indicates that drive level, when considered independently of stimulus intensity, was not significantly

Figure 7




Probability of Response "Hit" as a Function of the GSR Measure of Drive.

related to the frequency of response "hit." The significant Ss by Wing effect ($F=3.39$ $p < .01$ with 39 and 39 df) results from the differences in the two training drive levels. Ss trained under low drive give more "hit" responses to the weaker stimuli due to the shift under the low/high test condition, while Ss trained under high drive respond more frequently with "hit" to the stronger stimuli due to the shift under the high/low condition.

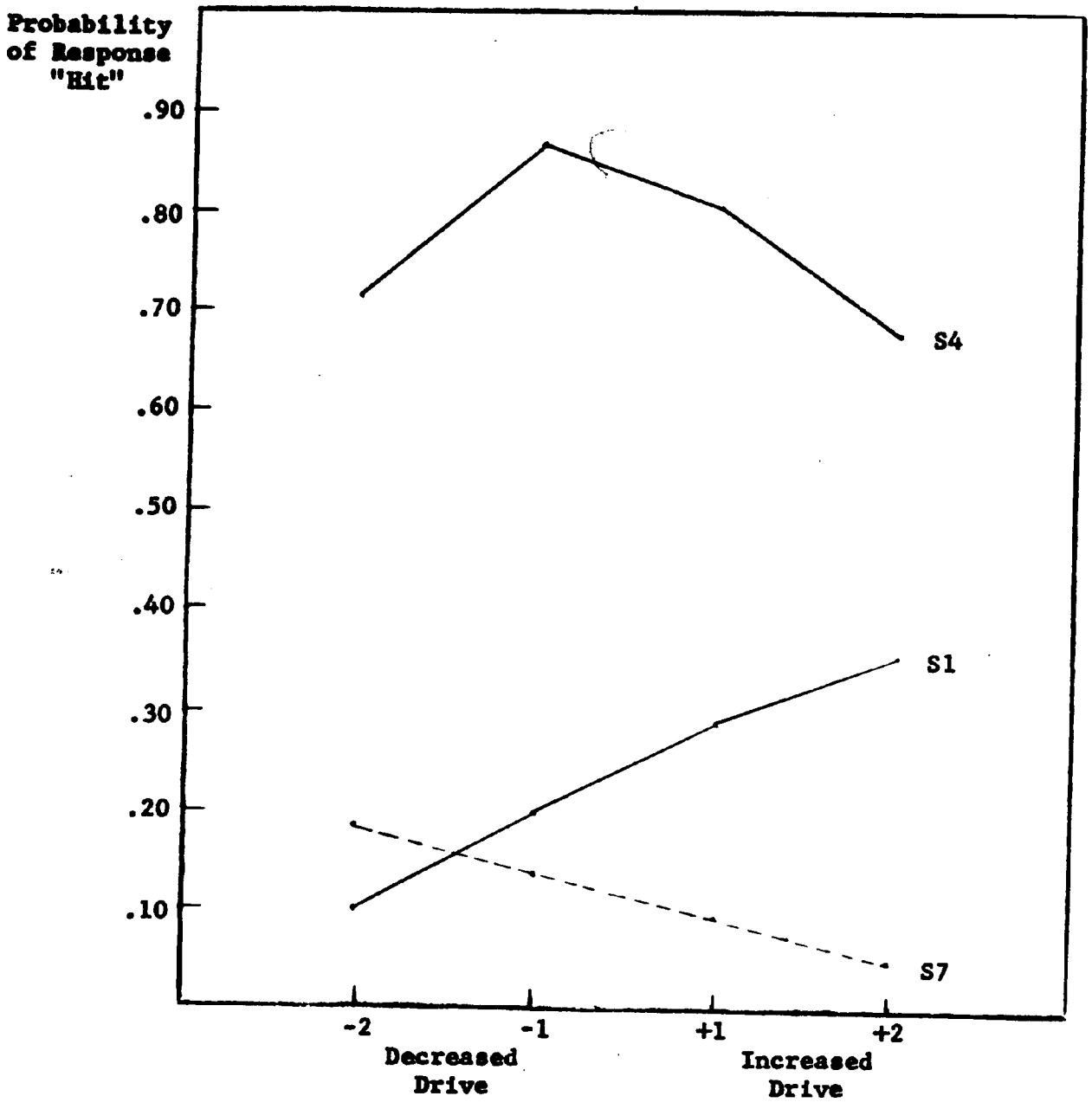
### C. Changes in the Probability of Response "Hit" as a Function of GSR Amplitude: Training Stimuli

In the preceding sections three theories of drive leading to different predictions concerning the effects of changing drive on stimulus generalization were examined. Dorfman's drive-stimulus interaction hypothesis proposes that drive affects perception by changing the scale value of stimuli on stimulus intensity dimensions. The Estes stimulus sampling model leads to the prediction that the presence of irrelevant drive stimuli decreases the probability of the dominant response. If it may be assumed that such irrelevant stimuli which have not been differentially associated with either response are, therefore, equally likely to elicit either response, the effect of such stimuli is to decrease the frequency of responses whose probability is greater than .5 but to increase the frequency of responses whose probability is less than .5. The Hull-Spence conception of drive as an energizer implies an increase in the dominant habit as a function of increased drive. The change in response frequency during test trials to stimuli S1, S4, and S7 used in the initial discrimination training will be used to test these three alternative theories of the effects of changes in drive on the probability of competing responses.

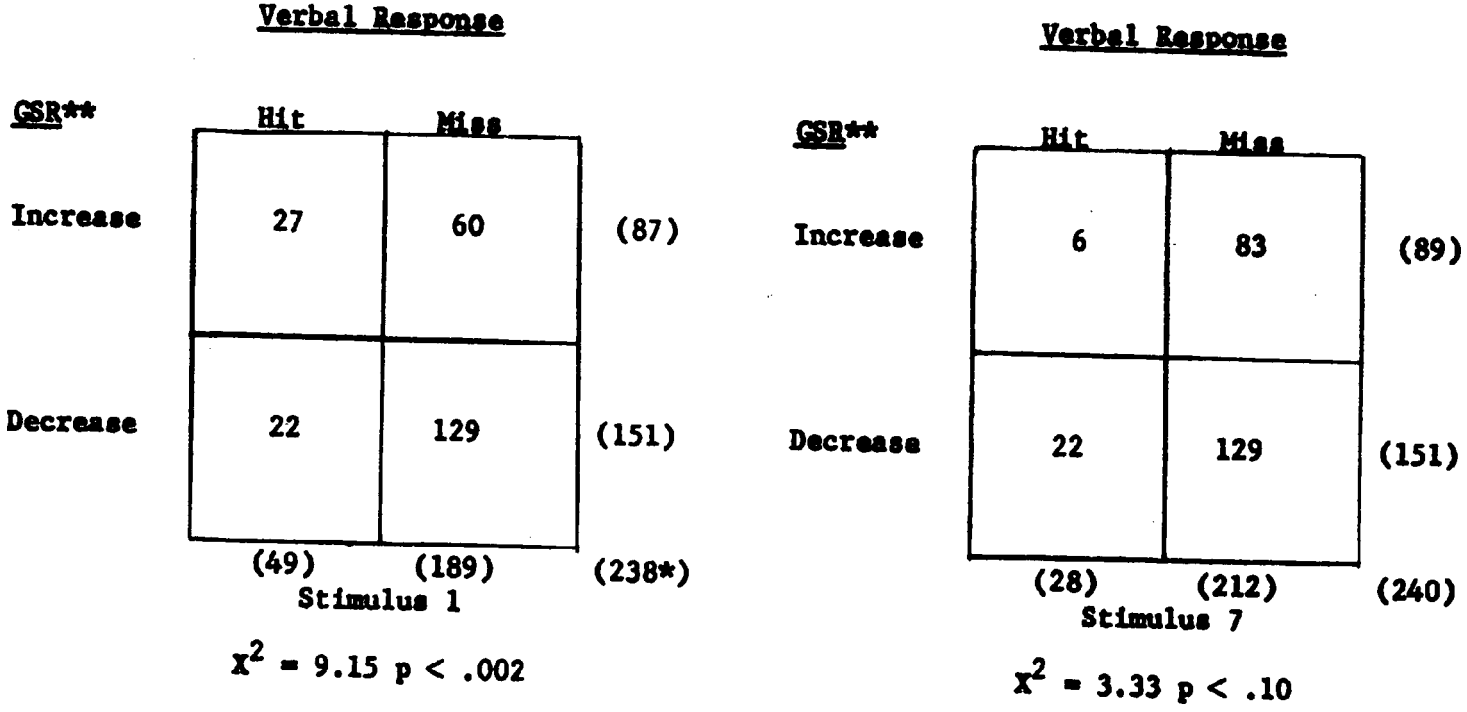
The probability of response "hit" to the three training stimuli as a function of drive change is presented in Figure 8. Change in drive was defined as the difference between the GSR shown during discrimination training and the subsequent generalization trials. Test trials showing decreased drive were divided at the median, with -2 indicating a large drop in drive level, and -1 a small decline in drive. Similarly, +1 indicates those trials accompanied by a small increase in drive relative to training, and +2 a large increase.

Examination of Figure 8 indicates that the effects of drive change are dependent upon stimulus intensity: a relative increase in drive increases the probability of response "hit" to S1, decreases it to S7, and appears to be curvilinearly related to response "hit" to S4. Table 9 presents the $X^2$ test of independence between the verbal responses and direction of drive change for stimuli S1 and S7. Increase in drive is associated with a <u>decrease</u> in the probability of the dominant response "miss" to S1 ($X^2$=9.15, $p<.002$ with 1df), but appears to be associated with an <u>increase</u> in the probability of the dominant response to S7 ($X^2$=3.33, $p < .10$ with 1df.) The second order interaction is also significant ($X^2$=10.42, $p <.002$ with 1df), indicating that increasing drive has an opposite effect on response probability for the two negative training stimuli. This effect is consistent with the drive-stimulus interaction hypothesis since the effect of the drive produced increment in effective stimulus intensity depends upon whether this increment increases or decreases the similarity between the test stimulus and the positive training stimulus. For S1 this increment in effective stimulus intensity increases the similarity and is reflected in an increased probability of response "hit"; for S7, the increment increases the

Figure 8




Response Probability as a Function of Change in Drive from Training to Test




Second Order Interaction: $X^2 = 10.42$ $p < .002$

*Two trials were omitted due to failure to obtain a readable GSR record.
**Score: Increase = GSR during a given test trial was greater than the mean GSR during discrimination training.

Table 9

Response Probability as a Function of Change in Drive from Training to Test

difference in intensity between S4 and S7, and is, therefore, associated with a decrease in the probability of response "hit."

It may be noted that no inhibition effects were produced by the simultaneous arousal of fear. Even the strongest fear responses are associated with facilitation or increment in effective stimulus intensity. Generally it is assumed that the optimal condition for demonstrating inhibition involves a psychophysical response made to a stimulus of weak intensity whose "discharging circuit will not outlast the inhibitory actions." (Blum, 1961, p. 48) The sound intensity used in the present experiment was well above threshold and of a relatively long duration (1 second). Conceivably, if the intensity and duration of the sound stimuli were reduced, fear would produce an inhibitory effect which would be reflected in a negative relation between the probability of response "hit" and GSR amplitude to stimulus 1 a positive relation for stimulus 7.

This significant second order interaction is difficult to handle within the theories of Estes and Hull-Spence. Since S1 and S7 have received an equal number of reinforcements during discrimination training and the probability of response "miss" is greater than .5 for each, Estes should predict either that increasing drive should decrease its probability to both stimuli, or, if the drive stimuli do not have associative strength, have no effect on response probability. In either case the theory does not handle the differential effect related to stimulus intensity which is produced by the change in drive.

Hull and Spense face a similar problem in accounting for the differential drive effects related to stimulus intensity. The change

in $S_D$ is the same for test trials at S1 and S7, and the response strength of the dominant response greater than .5 and roughly equivalent for both. Thus, one would expect that the D x H formula would predict that the probability of response "miss" should increase with increasing drive for both stimuli instead of showing an increase for S1 and a decrease for S7. This differential effect can only be accounted for by making ad hoc assumptions about the extent to which the competing reaction potentials for response "hit" and "miss" are above threshold.

An examination of the response probability curve for the positive training stimulus, S4, is also instructive. At this point change in drive, whether representing an increase or decrease in drive from training to test trials, lowers the probability of the dominant response. Table 10 indicates that those trials characterized by a large change in drive show a significant decrease in the frequency of response "hit" as compared to trials showing a smaller change in drive from the training level. ($X^2=4.08$, $p < .05$ with 1 df) This is interpreted to mean that lowering drive decreases effective stimulus intensity such that stimulus S4 is now perceived as more like stimulus S1 with a consequent increase in the probability of response "miss"; while raising drive level increases effective stimulus intensity such that the probability of response "miss" generalized from S7 is subsequently increased.

If this interpretation is correct, the relationship between the drive level during test trials and the probability of response "hit" will depend upon the training drive level rather than upon the habit strength of the "hit" response. When drive is lowered from training to test (high/low), response "hit" should be more frequent on those

Table 10

Changes in Response Probability as a Function of Change in Drive: S4

| | Verbal Response | | |
|---|---|---|---|
| Change in D | HIT | MISS | |
| Large | 82.5 | 33.5 | 116 |
| Small | 95.5 | 20.5 | 116 |
| | 128 | 54 | 232* |

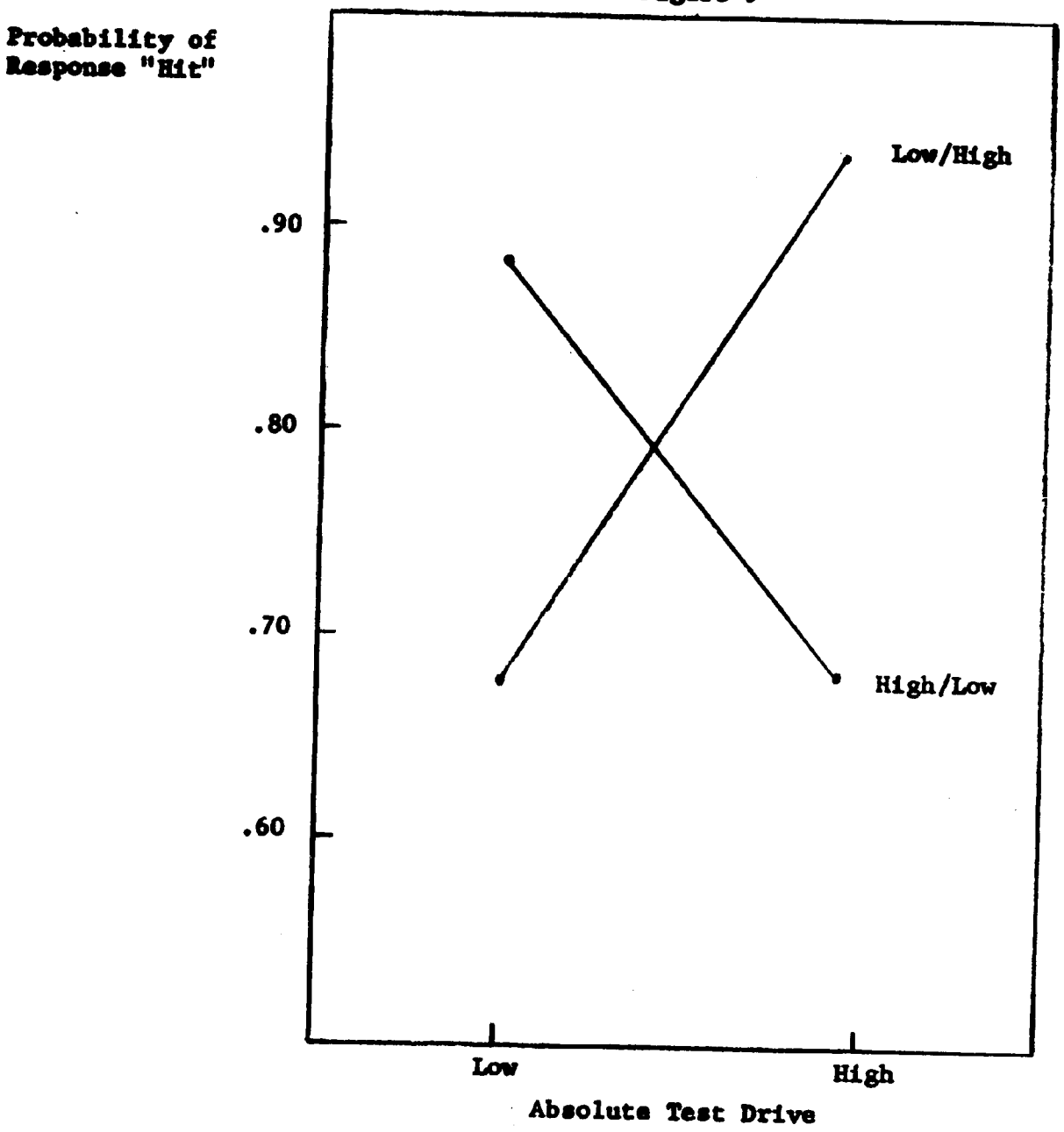
$X^2=4.08$ $p < .05$ with 1 df.

*Eight trials omitted due to failure to obtain readable GSR record.

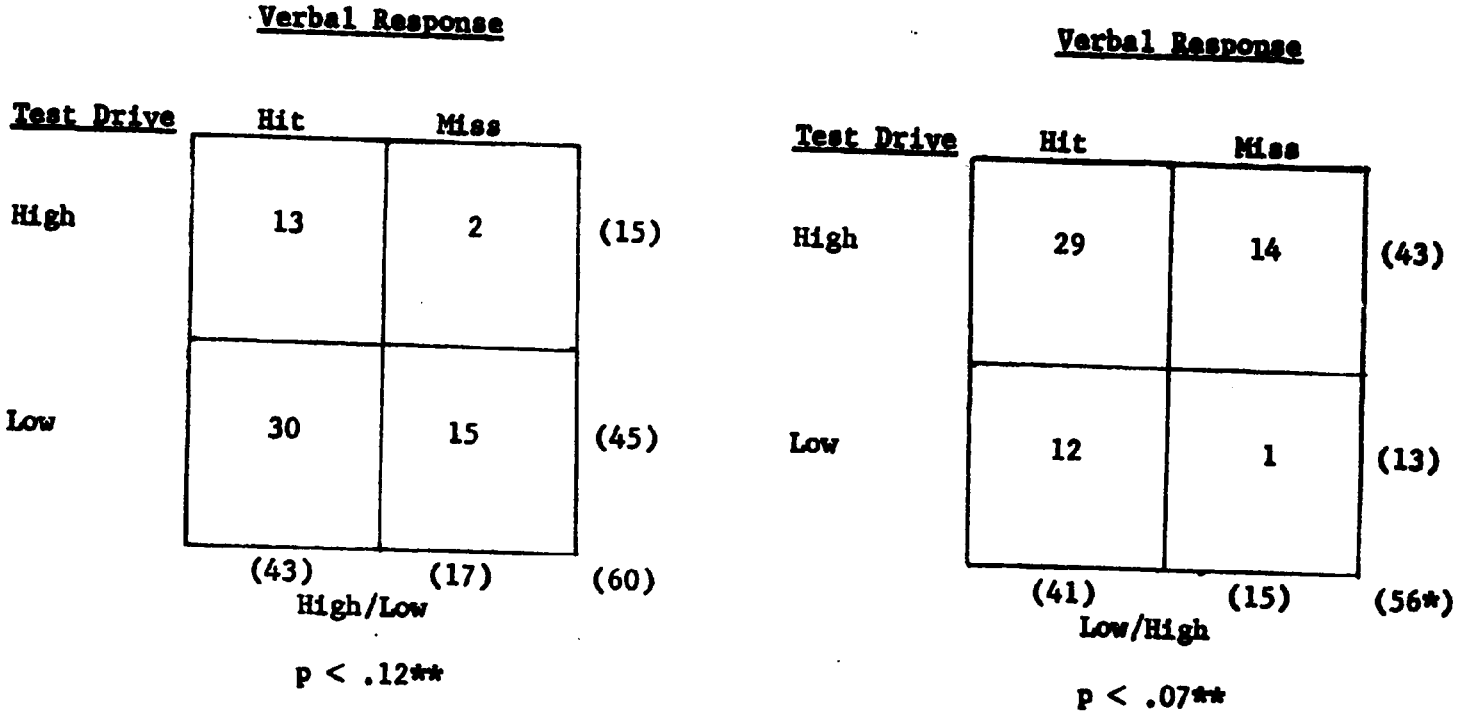
test trials when the GSR indicates high rather than low drive. Low drive trials, by decreasing the effective stimulus intensity of S4 result in S4 eliciting more "miss" responses generalized from S1. However, when drive is increased from training to test (low/high), the probability of response "hit" should be greater on low rather than high drive trials, as assessed by the GSR. In this case high test drive trials indicate an increment in effective stimulus intensity for S4, thus causing it to elicit more "miss" responses generalized from S7.

The trials under the combined low/high and high/low conditions were divided at the median in terms of the amplitude of the GSR shown during test trials. Examination of Figure 9 and Table 11 indicates that

Figure 9




Response Probability as a Function of Absolute Test Drive: Stimulus S4




Second Order Interaction: $p < .02$**

*Four trials missing because of GSR record.
**Exact probabilities for $X^2$. (R. A. Fisher, Statistical Methods for Research Workers, New York, 1950. 11th edition)

Table 11

Response Probability as a Function of Absolute Test Drive: Stimulus 4.

the effect of the test drive does not depend upon the probability of response "hit" since it is nearly equal under the two test conditions ($p=.72$ for the high/low trials and .73 for the low/high trials). Rather the change in the probability of response "hit" depends upon the relationship between the training and test drive levels. For the group trained under low drive, increase in the test drive level is accompanied by a decrease in response "hit" ($p < .07$). However, subjects trained under high drive show an increase in the probability of response "hit" as the test drive level increases ($p < .12$). The second order interaction is significant at the .02 level of confidence. Thus, one cannot predict the effects of the test drive level on response probability without also knowing the drive level during the training period.

One may conclude from these data that changing drive level has three different effects on response probability depending upon the intensity of the training stimulus, and that the effects on the probability of response "hit" associated with Stimulus S4 depend upon the training drive level. These effects are consistent with and predicted by a drive-stimulus interaction hypothesis which assumes that drives have sensory or stimulus effects and act to increase the perceived intensity of stimulation. Behavior theories which assume that drives have only response effects and that these response effects are related to the association strength of the response conditioned to a given stimulus do not handle these data without resorting to special ad hoc assumptions.

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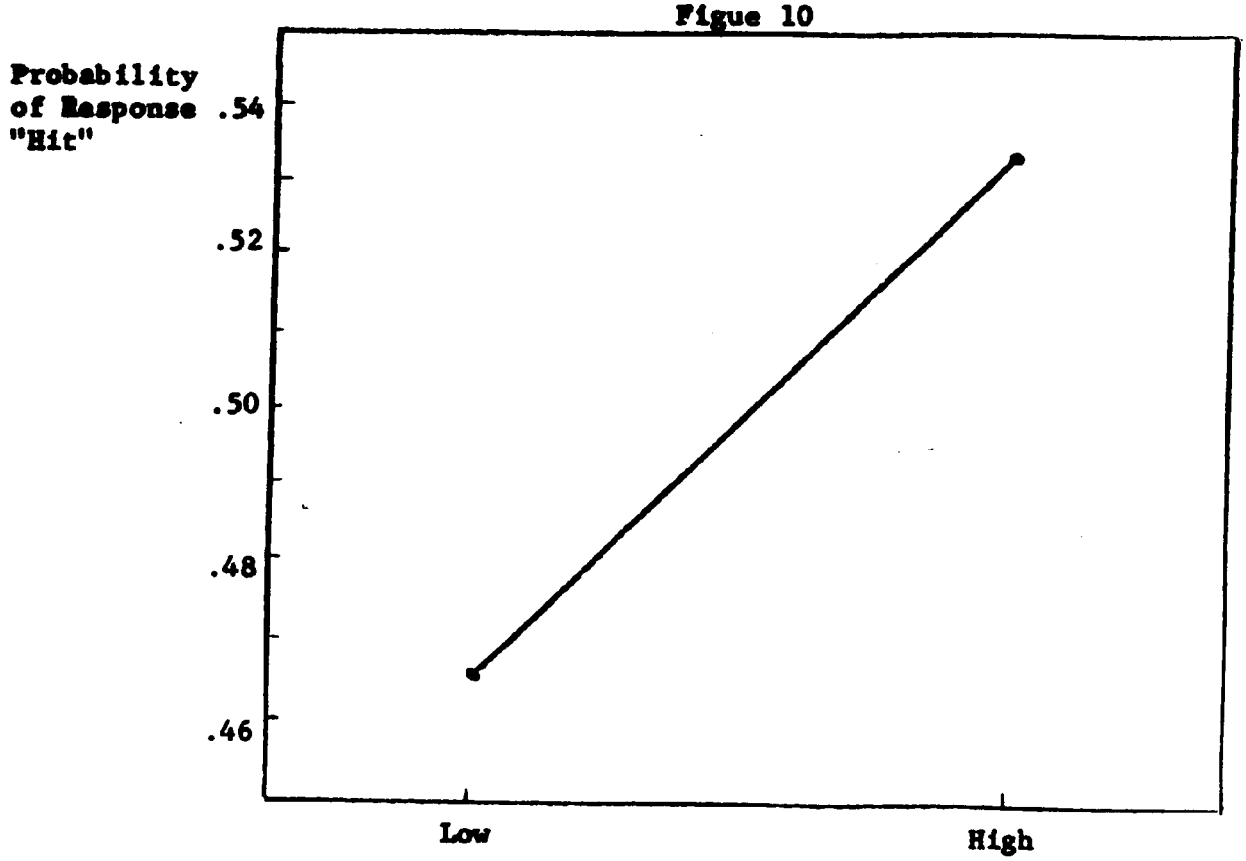
### D. The Effect of Drive on the Probability of Response "Hit" Where Pr(hit)=Pr(miss)

A critical test of theories which hypothesize response effects of changes in drive occurs in the situation where the probabilities of the competing responses are equal. In the present study the probability of response "hit" was exactly .5 to S3. On the 240 trials, 120 "hit" and 120 "miss" responses were given. In order to test the effects of change in drive where Pr(hit) = .5, the six stimulus presentations for each subject were divided into 3 high and 3 low drive trials, and the frequency of the "hit" response tabulated for each condition. These data are presented in Figure 10. The probability of response "hit" increases as a function of drive level from .466 to .534. Within the drive-stimulus interaction framework this is interpreted to mean that an increase in the drive produced increment in stimulus intensity causes S3 to pick up more of the habit strength of response "hit" generalized from S4.

These data are not easily handled within the Estes' stimulus sampling model. Drive stimuli, since they have not been differentially associated with either response, may be presumed to have a probability of .5 of eliciting either response. In the present context, if Pr(hit) = Pr(miss) = .5, the addition or subtraction of drive stimuli would, therefore, have no effect. If it is assumed that Pr(miss)>Pr(hit), the addition of drive stimuli would increase the Pr(hit) but, since drive stimuli only have an association value of .5, they could not increase it beyond .5. And Finally, if Pr(hit)>Pr(miss) drive stimuli should decrease

the probability of the hit response. Clearly, none of these cases fit the response curve shown in Figure 10.

Figue 10




Response Probability as a Function of Change in Drive: Stimulus 3

The predictions of the Hull-Spence theory concerning response effects of drive in a discrimination problem are more complicated since drive is assumed to affect not only the relative strength of the competing reaction potentials $\left[E_{hit} - E_{miss} = D(H_{hit} - H_{miss})\right]$ but also the degree to which they are above threshold (Spence, 1956). Given a constant difference between the reaction potentials of two competing habits, the probability of the dominant response is at a maximum when

the distribution of the momentary reaction potentials of the stronger response is at least partially above threshold while that of the weaker response is entirely below threshold. The probability of the stronger habit gradually decreases to a minimum as the distribution of reaction potentials of the weaker habit also becomes largely supra-threshold. Thus, although it increases the difference between two competing reaction potentials, drive may paradoxically lower the probability of the stronger habit by also raising the distribution of reaction potentials of the weaker response partially above threshold. The effect of drive on the probability of response "hit", then, will depend upon two factors: (1) the relative strength of the two reaction potentials, and (2) the degree to which they are above threshold. Since neither of these can be specified exactly in the present context, the four possible combinations are presented below (Table 12, Page 92) along with their behavioral implications.

Examination of Table 12 shows that only cells B and C are consistent with the data presented in Figure 10. Although drive may decrease the <u>probability</u> of the dominant habit by changing the degree to which the reaction potentials are above threshold, the probability will almost always be greater than .5. Since drive also increases the difference between the reaction potentials of competing habits, the relative dominance of the habits will be maintained. Thus, cell B is consistent with the data in predicting an increase in Pr(hit), but the assumption, $E_h > E_m$, is clearly inconsistent with the obtained probability of response "hit" during the low drive trials. Similarly, cell C is correct but $E_m$ cannot be greater than $E_h$ because the probability of

Table 12

Predicted Effects of Drive on Response Probability: Hull-Spence

| Relative Reaction Potential * | Threshold ** | |
|---|---|---|
| | Partly Above | Completely Above |
| $E_h > E_m$ | A<br>Pr(miss) may increase | B<br>Pr(hit) increases |
| $E_m > E_h$ | C<br>Pr(hit) may increase | D<br>Pr(miss) increases |

* $E_h$: excitatory reaction potential of response "hit."

** The degree to which both reaction potentials are above or below the response thresholds.

response "hit" is greater than .5 for the high drive trials. The single remaining alternative, that $E_h = E_m$, implies that $E_h - E_m = D(H_h - H_m) = 0$. That is, if the probability of both responses is .5, drive will not be related to the response probability curves. The predictions presented in Table 12 highlight the difficulty the Hull-Spence theory has in accounting for the probability of the "hit" response to S3 where low drive is associated with a probability of less than .5, and high drive trials with a probability greater than .5.

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## SUMMARY AND DISCUSSION

In Section III several derivations of the drive-stimulus interaction hypothesis concerning the interrelationship between a physiological assessment of drive (GSR), physical stimulus intensity, and probability of competing verbal responses were presented and, in general, confirmed. Section A presented data showing that the mean GSR accompanying response "hit" decreases as a function of physical stimulus intensity, while that accompanying the "miss" response increases. In Section B the prediction that Pr(hit) increases as a function of the GSR amplitude for the weaker stimuli, but decreases for the stronger was confirmed. The relationship between GSR and response probability to the training stimuli was discussed in Section C, with results parallel to those of Section B. In addition, it was noted that the probability of response "hit" to S4 decreased if the drive level was either raised or lowered from the training to the test period. The final section demonstrated that changes in drive were systematically related to response probability even when the over-all probability of the competing responses was identical.

Although these data were adequately handled by the drive-stimulus interaction hypothesis, they are difficult to handle within behavior theories which assume that the effect of drive depends upon the strength of the S-R bend. The nature of these difficulties may be most easily illustrated in connection with the effect of drive on the probability of response "hit" to the training stimuli S1 and S7 (Section C). Here it was shown that increasing drive from training to test <u>increased</u> the probability of the dominant response to S7, but <u>decreased</u> it to S1. Since drive stimuli may be assumed to have a fixed associative strength

with response "hit", a stimulus sampling model cannot adequately handle the differential effect of drive on response probability for the S1 and S7 trials. The Hull-Spence theory may handle this effect by means of an *ad hoc* assumption. If the reaction potentials of the two competing responses are largely below threshold for S1, but largely above threshold for S7, an increase in drive would decrease the probability of the stronger response to S1, but increase it to S7. However, since an equal number of training trials was given at each stimulus, there seems to be no compelling evidence from the procedure or the data which would support this assumption. In light of the difficulties which traditional behavior theories have in accounting for these drive effects, it was concluded that the drive-stimulus interaction hypothesis was supported and that drives may have stimulus as well as response effects.

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B

# CHAPTER III

## CONCLUSION AND IMPLICATIONS FOR FUTURE RESEARCH

The study reported here concerning the effects of conditioned fear on the perceived intensity of sound stimulation is one of a series of studies testing the hypothesis that motivation affects perception by changing the scale value of stimuli on intensity dimensions. Two kinds of evidence were offered in support of this thesis: (1) shifts in the stimulus generalization curves following changes in drive level which were consistent with and predicted by the hypothesis that effective stimulus intensity is a joint function of momentary drive level and physical stimulus intensity, and (2) changes in skin conductivity which were systematically related to the response probability associated with stimuli used in testing for stimulus generalization. Specifically, it was found that increasing drive from training to test displaced the generalization curves toward the weaker physical stimulus intensities, and decreasing drive displaced the curves toward the stronger stimulus intensities. When the GSR was used as a measure of observed drive level, it was noted that changes in response probability as a function of changes in drive from training to test depended upon whether the test stimulus was weaker or stronger than the positive training stimulus. Increasing drive lowered the probability of the dominant response associated with the weaker stimulus intensities, but increased it for the stronger stimulus intensities. It was argued that these results indicate that drives have stimulus effects: $S'=f(D,S)$; and that these effects are not adequately handled by the response interpretations offered by current behavior theories.

However, some precautionary studies would be desirable before firmly committing oneself to this interpretation. The procedure in the present study tested for generalization effects following minus-plus-minus discrimination training rather than the more conventional single point training. This procedure results in a curve of generalized response strength being generated about each of three training stimuli such that the response probability associated with a given stimulus is a joint function produced by the interaction of three curves. Since drive is known to produce systematic changes in generalized response strength, it might be possible to handle the present results in terms of the Hull-Spence theory of response effects of drive without the necessity of postulating additional stimulus effects. It would be reassuring to know that the present results could be duplicated using training to a single stimulus. The difficulty, of course, lies in producing a generalization curve steep enough within the narrow stimulus range which must be used to demonstrate the drive-stimulus interaction effect.

A second precautionary study involves the use of a qualitative dimension such as pitch with the identical procedure of the present study. The drive-stimulus interaction hypothesis postulate stimulus effects of drive only on quantitative or intensity dimensions. Since a response interpretation of the shift in the generalization curves would be based on the relative strengths of the competing habits conditioned to a stimulus rather than upon stimulus characteristics per se, negative results in such a study, especially if the identical three point training procedure were used, would strengthen the interpretation in terms of stimulus effects of drive given here. Such results would show that the

displacement is not an artifact of a particular training procedure, and that a response interpretation is inconsistent when both sets of data are considered.

If drives do, in fact, have stimulus effects, it should be possible to detect them using other data collection procedures. An immediate extension of the thesis would involve testing the effects of conditioned fear on detection threshold and psychophysical judgments. This study is comparable to the study by Dorfman (1960) which reports the effects of drive producing sound on psychophysical responses to tactual stimulation.

In the first chapter several areas of research were reviewed for evidence of perceptual effects of motivation. The research cited as evidence for such an effect may be roughly divided into three categories: (1) studies on the accentuation of size judgments as a function of the incentive value of the judged stimulus; (2) vigilance-defense experiments relating the affective value of the stimulus to recognition threshold; and (3) sensory interaction studies. The drive-stimulus interaction hypothesis provides a powerful tool not only for explaining and interpreting the results of these experiments within a more inclusive behavior theory, but also for generating new leads for subsequent research. Several experiments suggested by this hypothesis which are related to these research areas will be considered in detail below.

## Accentuation Studies

Two alternative interpretations of the accentuation phenomenon will be considered here since they lead to somewhat different behavioral predictions. Bruner and Postman, while originally espousing a motivational

enhancement theory, seem to have abandoned it for what may be called a correlational model (Bruner, 1951; Postman, 1953). If two dimensions upon which a stimulus may be located are correlated, the location of the stimulus on one dimension will affect its judged location on a second. Thus, if in our culture "bigger" carries the connotation of "better" or "more valuable", coins will be perceived as larger in "confirmation of a motivational or personality related hypothesis" (Bruner, 1951).

In contrast to this expectancy model, Dorfman (1960) has argued that accentuation effects may be explained in terms of the general energizing effect of drive such that perceived size increases as a function of drive arousal: $S'=f(S,K)$, where K is the incentive value of the stimulus. Since this effect is assumed to operate only on intensity judgments, this hypothesis and the Bruner-Postman expectancy hypothesis may be contrasted using a modification of the Lambert, Solomon, and Watson procedure (1949). Suppose that a differential reinforcement procedure is used pairing a large red poker chip with candy reward, and a smaller pink chip with no reward. This association of stimulus attributes with the end points of a value series should lead, according to Bruner and Postman, to an accentuation of these cue properties of the stimulus which signify reward. After reinforcement, both size and redness of the positive stimulus should be accentuated in comparison with pre-training judgments. This effect may be compared to a similar process in social perception in which a "halo" effect is produced because judgments of different attributes of the stimulus are not independent (cf. Campbell, 1956).

In contrast, the drive-stimulus interaction hypothesis predicts accentuation of size only, and cannot handle the change in scale value on a qualitative dimension if it occurs. If judgments of both size and color are enhanced, an association interpretation is favored; if perceived size alone changes, a general energizing effect of drive on perceived stimulus intensity is suggested.

A more direct test of the two theories is possible by contrasting the effects produced by a training procedure associating reward with the smaller as compared to the larger stimuli of a series (Tajfel, 1959; Turnbull, 1959). In this case, the Bruner-Postman hypothesis predicts an underestimation of size in the former case, and overestimation in the latter. The drive-stimulus interaction hypothesis predicts that both training procedures would lead to accentuation effects, although the relative accentuation of specific stimuli may be determined by differences in training and their location on the stimulus dimension. Since the studies using this procedure were not designed with a drive-stimulus interaction theory in mind, their results are not unambiguous for contrasting the two theories. Even if "smallness-reward" training leads to smaller estimates than "largeness" training, a comparison of the former with pre-training estimates is crucial. If size estimates after "smallness-reward" training are at all larger than pre-training estimates, it is impossible to determine whether this residual overestimation is due to the accentuation effect of drive or simply reflects a failure to completely extinguish a built-in association between largeness and value.

## Recognition Thresholds of Need Related Stimuli

Since the drive-stimulus interaction hypothesis assumes the effect of drive to be general rather than specific, it predicts somewhat different consequences than do the minimax and vigilance and defense theories. For instance, in determining the effect of need on recognition threshold, it would be predicted that if response biasing were controlled by the use of a suitable forced choice technique (such as that employed by Blum, 1954, 1955), thresholds for both need-relevant and need-irrelevant stimuli would be lowered. The former might show a relatively greater drop if it is assumed that the perception of a goal related stimulus is either drive arousing or elicits a fractional anticipatory goal response which has emotional components. But, in general, the arousal of an irrelevant drive should have the same effect as the arousal of a stimulus relevant drive.

In the vigilance-defense area Blum (1954) in an ingenious experiment has shown vigilance effects at short stimulus exposure times and defense effects at longer exposures. This finding is of considerable interest in the present context since it is in direct opposition to what might be predicted from a drive-stimulus interaction hypothesis. The probability of naming the correct time interval in which the neutral stimulus occurs should increase monotonically with stimulus duration. For exposition purposes we will consider this relation to be linear (Figure 11). Following Blum's derivation of differences in ego functioning under different conditions of stimulus presentation, recognition accuracy should be higher for an anxiety producing stimulus as compared to a

neutral stimulus at short stimulus durations, but lower at longer stimulus durations. In contrast, the drive-stimulus interaction predicts greater sensitization to the threatening stimulus as a function of stimulus duration such that the accuracy curve shows increasing divergence from that of the neutral stimulus. This follows from the assumption that the probability of occurrence and strength of the fear response increases as a function of stimulus duration.

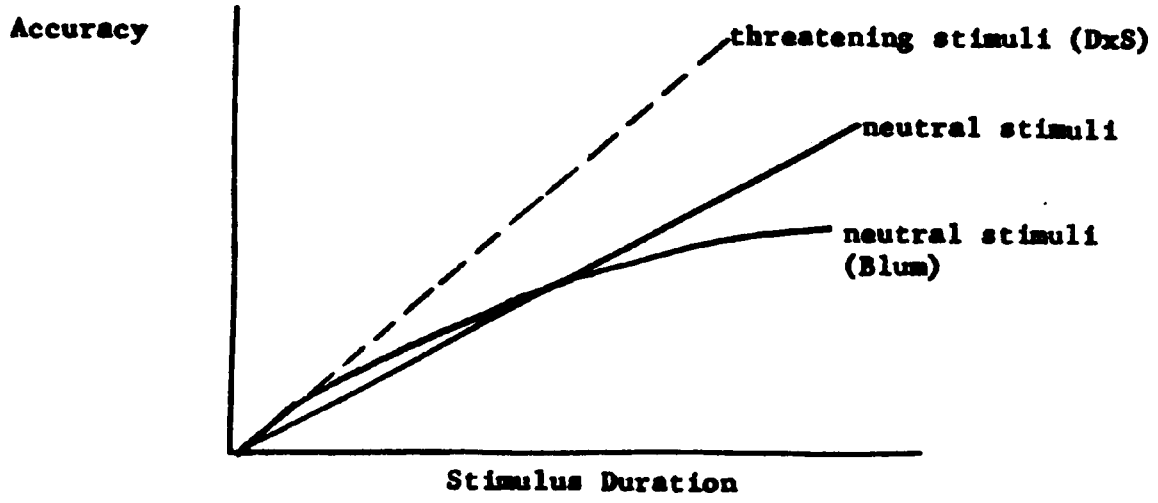



Figure 11

Recognition Accuracy of Neutral and Threatening Stimuli

As exposure time is increased, drive level also increases, resulting in a greater enhancement of effective stimulus intensity and a consequent lowering of threshold.

The foregoing experiment rests on the assumption that perceptual defense is not simply a response effect. If looking at a stimulus arouses fear, looking away with the consequent reduction of perceived stimulus intensity will be learned by reduction of fear. Stimuli may

be discriminable before recognition (naming) occurs (Eriksen, 1960), and it is at least conceivable that this distinctiveness in sensory experience is sufficient to cue off a discriminated anxiety response which interferes with the correct labeling of the stimulus.

Sensory Interaction

Dorfman (1960) has proposed that sensory interaction effects may be explained by assuming that the extraneous stimulus is drive producing and that the aroused drive increases the effective or perceived intensity of the judged stimulus. This leads to the prediction that any operation which changes the drive characteristics of a stimulus will have consequences for sensory interaction. The acquisition of drive properties through conditioning or secondary reward training should enhance the interaction; adaptation trials to the extraneous stimulus preceding testing or the ingestion of depressant drugs should reduce the effect. Changes in psychophysical responses produced by sensory interaction become an alternative measure of drive or the arousal value of stimulation and may be used to evaluate the effectiveness of drive conditioning. For instance, either the acquired drive or the reward value of a stimulus as a function of different training procedures might be assessed by means of differences produced in sensory interaction. This might be compared to a similar use of the sensory interaction effect by Brogden and Gregg (1951) to demonstrate the existence of presensory conditioning. Subjects who had previously experienced the pairing of an extraneous stimulus with the test stimulus at supra-threshold values showed a greater drop in threshold with simultaneous presentation of the extraneous stimulus than did subjects not given prior training.

The drive-stimulus interaction theory has implications for psychophysical data quite apart from its relevance for sensory interaction. Individual differences in sensory thresholds may be partly attributable to the accentuation effects of drive on stimulus intensity. Physiological measures such as blood pressure or basal skin resistance to electric current which are assumed to reflect reticular activity (Lindsley, 1951) or assessment procedures used to measure drive level such as the Manifest Anxiety Scale should show certain systematic relations to threshold determinations. If the drive-stimulus interaction hypothesis is true, subjects whose drive level is characterized as high should show lower thresholds than subjects whose drive level is low. Diamond (1960) has shown stimulus enhancement effects related to blood pressure level but it remains to be demonstrated that similar effects can be found in a signal detection task.

## Implications of Drive Produced Stimulus Effects for Discrimination Learning

The drive-stimulus interaction hypothesis has obvious relevance to successive discrimination learning. If, for instance, the task consists of learning to differentiate between two stimuli of different intensities, the effect of drive will differ depending upon whether it is aroused when the less intense stimulus is presented, or when the more intense stimulus is, or if it is aroused during the presentation of both. In the first case the predicted effect of drive is to hinder discrimination learning; in the second, to facilitate discrimination learning, and in the last, its effect depends upon the precise function relating drive and stimulus intensity. Since drive increases effective stimulus intensity, the weaker stimulus under high drive will be less discriminable

from the stronger stimulus than when presented under low drive. However, the stronger stimulus will be more discriminable from the weaker stimulus under high rather than low drive. Consequently, during the course of learning, subjects should show more errors to the weak stimulus on high than on low drive trials, but fewer errors to the strong stimulus on high as compared to low drive trials.

In the present experiment in which stimulus generalizations was tested subsequent to discrimination training it was shown that changes in response probability as a function of change in drive depend upon the relation between the intensities of the test and positive training stimuli rather than upon the relative strengths of the competing habits associated with each test stimulus. Similarly, in discrimination learning it seems reasonable to expect that the effect of drive on response probability will not only depend upon the energizing effect of drive on habit strength but also upon its accentuation effect on perceived stimulus intensity. In short, drive is assumed to have both a stimulus effect (DxS) and a response effect (DxH) which are operative in drive produced changes in performance.*

## SUMMARY

The present study represents one of a series of tests of the hypothesis that drives affect the location of stimuli on intensity dimensions. This modification of Hull-Spence behavior theory provides one approach for attacking the problems of perception within a theory which has already proved extremely useful in studying learning phenomena (Spence, 1956) and suggestive in the areas of personality research

*This prediction was not confirmed in a successive discrimination learning problem using sound as the cue and shock as the drive producing stimulus.

(Eysenck, 1957; Dollard and Miller, 1950) and social phenomena (Campbell, 1956). It was argued that the drive-stimulus interaction hypothesis is consistent with the experimental data on perceptual effects of motivation, and provides a powerful tool both for integrating these data and for suggesting new tests of this interaction. Implications of the hypothesis were spelled out for accentuation effects, drive effects on recognition threshold, sensory interaction, and discrimination learning.

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