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EFFECTS OF AROUSAL
ON EPISTEMIC BEHAVIOR

by

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Effects of Arousal on Epistemic Behavior

BY

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INTRODUCTION

While humans and animals have always shown an active interest in and curiosity about their environments, it is only within the relatively recent past that psychologists have begun to direct their interest, curiosity, and attention to this type of behavior. After attempting to fit exploration and curiosity in the framework of a drive reduction position (e.g., Berlyne, 1960), it soon became apparent that the behavior could not be cut to fit existing theories, and new ways of looking at the behavior developed.

Cofer and Appley (1964) summarized the problem and said, "In the decade of the 1950's, doubt was increasingly expressed as to the adequacy of internal states...to account for many of the behaviors in which organisms engage. One important facet of this doubt has arisen with regard to behavior that explores or manipulates the environment or which appears to raise the stimulation level to which the organism is subjected. Terms like curiosity, exploratory drive, manipulation motive, stimulus hunger, or the need for stimulation, have come into vogue and there has been a clear implication that the phenomena designated by these concepts cannot be explained in terms of, or reduced to, or derived from, internal processes, (e.g., hunger, thirst, sex).... These phenomena are not seen as learned but would probably be postulated as representing basic, unlearned characteristics of organisms." (Cofer and Appley, 1964, p. 277).

Exploratory and curiosity behavior involves dealing with new

sources of stimulus input to the organism. Terms such as novelty, complexity, surprisingness, and incongruity have been used to describe the properties of the stimuli that have an effect on exploratory behavior. Presentation of stimulus configurations containing these properties leads, within limits, to increases in the amount of exploration an organism shows. Further, it has been shown that organisms will learn an instrumental response which leads to an increase in the amount of stimulation to which they are exposed. Research has shown that more time has been spent by animals exploring, and by humans looking at, more complex stimulus patterns when the complexity of the stimulus is not extremely high (Berlyne, 1960, 1963; Berlyne and Lawrence, 1964; Berlyne and Lewis, 1963; Karmel, 1966; Wood and Davidson, 1964). Novel figures, stimuli never previously encountered, or stimuli not seen for some time, also increase the amount of exploration time (Berlyne, 1960; Bindra and Spinner, 1958; Fiske and Maddi, 1961). Surprisingness, or the presentation of unexpected stimuli, has a similar effect (Berlyne, 1963).

There are limits to the increases in exploration that an organism will show and, under certain conditions, decreases will follow presentation of new or complex stimuli. Rats placed in an extremely novel situation will not explore the stimuli present and, if given a chance, will withdraw (Berlyne, 1960, 1966). Blocking escape from the situation leads to fearful responses, e.g., crouching, defecation, etc. Similar results have been found with humans. In a choice situation, humans will look at more complex stimuli for a longer period of time than they will look at less complex stimuli; but an increase in novelty or complexity in the stimulus situation prior to choice leads to a decrease in the amount of complexity which the person choses (Berlyne, 1960; Berlyne

and Lewis, 1963; Haywood, 1961; McReynolds, 1962).

The above studies relate to the behavioral effects of the presentation of novel stimulus patterns and configurations. The type of exploratory behavior that ensues has been labeled by Berlyne (1960) as specific exploration. Spontaneous activity that an organism shows which leads to increased stimulation has been termed by Berlyne, diversive exploration. Diversive exploration is effected by the same variables, novelty, complexity, etc., that effect specific exploration.

Diversive exploration is exemplified by the studies that show that: a) rats tend to enter the opposite arm of a maze from that which they entered on a previous trial or they will enter the same arm if some change has been made in that arm (Berlyne, 1960); b) monkeys work in order to expose themselves to increases in stimulation (Berlyne, 1966); and, c) humans confined to the dark with little variation in stimulation will press buttons to make patterns of colored spots of light appear, showing a preference for patterns with the most variety and unpredictability (Berlyne, 1966). In other words, preliminary exposure to an unchanging situation increases the tendency to seek actively changes in stimulation, and the stimulus changes sought can involve any of the variables found to effect specific exploration, e.g., intensity, novelty, complexity.

Exploratory behavior of both types, appears to have motivational antecedents in that the absense of stimulation over a period of time increases the tendency of the organism to seek out new sources of stimulation and prolonged exposure to a novel stimulus situation eventually leads to a reduction in the amount of exploration shown. The motivational antecedents of exploratory behavior are of a different quality

than that seen in eating or drinking behavior. Neither specific deficits in bodily needs nor any noxious stimuli to be avoided or excaped from are apparent. In the attempt to deal theoretically with the findings on exploratory behavior, attention has become focused on the spontaneous and ongoing processes of organisms.

Exploratory behavior has been related to current theories of arousal. Arousal level is conceived to be a generalized physiological dimension indicative of how "awake," "alert," or "excited" an organism is at a given time. Some forms of exploratory behavior are accompanied by changes in the level of arousal, indexed by behavioral and physiological (e.g., EEG, GSR, EKG) correlates (Berlyne, 1966); and the stimulus variables that effect exploratory behavior are capable of changing the indices of arousal level. (See Berlyne, 1960; Fiske and Maddi, 1961, for further discussion.)

Berlyne (1967) categorized the variables effecting level of arousal into three types: a) psychophysical variables, e.g., the quantity or quality of stimulation, related to the physical or chemical properties of the stimulus; b) ecological variables, i.e., visceral and hormonal changes that accompany "drive," e.g., thirst, hunger, etc., as well as those changes that accompany conditioned aversive or rewarding stimuli; and, c) collative variables, e.g., novelty, complexity, incongruity, etc. Changes in the contribution to arousal from any of these sources effects the overall arousal level and the behavior of the organism.

Research findings tend to support the proposition that there is an optimum level of arousal at which functioning is most efficient. Levels below this optimum are characterized behaviorally by increasing alertness and increasing efficiency but at some point further below

the optimum level the organism shows inactivity and sleep. Above the optimum, there are increasing signs of disturbance, emotional behavior, anxiety, and disruption of behavior (Berlyne, 1960, 1967; Fiske and Maddi, 1961; Hebb, 1955; Lindsley, 1957). In other words, the relationship between efficient behavioral functioning and arousal can be described by an inverted U-shaped curve. Berlyne (1960) is one theorist in the area who maintains that the organism strives to maintain the level of arousal at, or near, the optimum. Fiske and Maddi (1961) have proposed that there are optimums for different periods in the daily life of the organism.

Berlyne (1960) and others hold that changes in arousal toward the optimum are reinforcing, changes in arousal away from the optimum are aversive. Hebb (1955) indicated that slight increases in arousal might be associated with positive reinforcement in that they might facilitate ongoing (neural) processes. Berlyne (1967) has recently taken a similar position, i.e., that increases in arousal might be sought for the positive effects that follow, while still maintaining that increases too far above the optimum are likely to result in behavioral disruption.

Organisms actively seek sources of arousal, i.e., environmental stimulation (collative variation) and it is possible that an optimum level of arousal can be maintained by regulation of the amount of incoming stimulation. When the arousal level is below optimum, the organism's own activity can bring it into contact with increases in collative variation, increasing the amount of arousal producing stimulation; and withdrawal from stimulation can decrease arousal when it is above an optimum level.

Berlyne's distinction between specific and diversive exploration

entails a difference between the conditions preceeding the manifestation of each type of behavior. Specific exploration occurs when the organism is presented with an environmental event (e.g., novel stimuli) which increases arousal. The final effect of specific exploration is a reduction in the arousal level (i.e., when familiarity with the stimulus reduces novelty). Diversive exploration, on the other hand, occurs when the arousal level is below the optimum, and the result of this type of exploratory behavior is an ultimate increase in arousal. Berlyne has maintained that specific epistemic behavior should occur upon presentation of a novel, or complex environmental stimulus, regardless of the arousal level at the time.

Collative environmental stimuli play an important role in human exploratory behavior and "epistemic curiosity." While some work has been done in studying human exploration of visually presented stimulation, little has been done to extend these findings to more complex activities. Not only do humans engage in exploration of visually presented stimulation ("perceptual curiosity"), but they also engage in activity which increases knowledge or symbolic information. Berlyne (1960, 1965) has held that gaps in knowledge, as well as incompatibilities in cognitive stimulus properties to which a person is exposed, leads to "epistemic curiosity." Curiosity is a motivational condition which leads an individual to deal with the situation in a manner behaviorally similar to the behavior shown following presentation of a novel, complex or other stimulus situation, i.e., curiosity is followed by the organism's exploring its environment. The motivation arises from, or is generated by, conflict induced by the stimulus input, conflict generated by the discrepancy between what is known or expected and what is presented. Berlyne has

held that a "conceptual conflict," i.e., "a conflict between incompatible, symbolic response patterns, beliefs, thought patterns, and ideas," is a source of arousal and can effect exploratory behavior of humans (Berlyne, 1965, p. 255).

Epistemic behavior is a form of exploratory behavior which augments knowledge and which leads to the resolution of conceptual conflicts. Berlyne outlined three classes of epistemic responses that serve to bring information to the person: a) epistemic observation, which brings the person into contact with external events which yield new information; b) epistemic thinking, e.g., productive and creative thinking; and, c) consultation, in which the person seeks information from other sources, i.e., asks questions, reads books, etc., (Berlyne, 1960, p. 265).

Some beginnings have been made in extending the research findings and the principles found in studies of exploratory behavior in animals and of studies on human perceptual exploration to human information seeking behavior (see Berlyne, 1960, 1965, 1967). For example, it has been found that variations in arousal level accompany "thinking" and covary with the degree of difficulty of the problem presented (Berlyne, 1965). The amount of curiosity that an individual reports has been shown to be a function of the amount of incongruity, novelty, etc., presented (Berlyne, 1960; Haywood and Hunt, 1963; McReynolds, 1962).

EXTENSIONS OF THE THEORY

As in every other aspect of behavior, people differ in the degree to which they engage in information seeking behavior. Similarly, differences exist in the amount of epistemic behavior displayed by the same person at different times. While the above ideas, generated from the study of exploratory behavior, allow for predictions concerning simple types of this behavior, certain theoretical extensions of the ideas have to be made to handle individual differences.

It can be assumed that the differences in the amount of epistemic behavior shown when an individual is presented with a conceptual conflict are regulated by at least two factors: 1. habit--some people characteristically engage in more of this behavior, probably because of past reinforcements for such behavior; and 2. anxiety--this or some other form of emotional state appears to produce increases and decreases in epistemic behavior.

Investigators have shown that measures of response strength and efficiency are curvilinearly related to arousal in a manner usually described as an inverted U-shaped curve. It is likely that the emotional component in individual differences in epistemic behavior can be explained in terms of arousal, and that epistemic behavior is related to arousal, as are other exploratory responses. That is, the tendency to engage in epistemic behavior will increase as arousal approaches some optimum level, and will decrease as arousal increases beyond this optimum. Further, this decrease will occur even when an individual is faced with a conceptual conflict, in contrast to Berlyne's expectation that specific exploration always will follow the presentation of a conceptual conflict.

There is some evidence to support the assumption that people characteristically operate under different levels of arousal, some closer to their optimum, some further away. Epistemic behavior results in increases in arousal and, if increases in arousal beyond an individual's optimum leads to reductions in epistemic behavior, individual characteristic arousal becomes an important factor in determining when the optimum arousal is exceeded and a reduction in epistemic behavior will occur.

Fiske and Maddi (1961) hold that the level of arousal is a result of the "impact" of all the stimulation occuring at a given time. And, Berlyne has recently stated that arousal might be looked at in a manner analogous to a generalized drive (1967). That is, the joint operation of two or more of the variables which effect arousal leads to changes similar to those accompanying an increase in the intensity of a single determinant. Thus, the effect of adding another source of stimulation to an organism at a given level of arousal would be to increase arousal level.

Figure 1 depicts the relationship of response to arousal. If, for example, an individual's characteristic level of arousal places him at point A, and he is then presented with a conceptual conflict, this additional arousal will put him at a new level, e.g., point AB. If epistemic behavior occurs, it would increase arousal even further, e.g., to point B, a position still on the ascending portion of the curve and below the assumed optimum, point C. Not only would it be expected that further epistemic behavior will follow, but also that the new level of arousal reached would not be aversive, and more likely be rewarding. Given an individual who is initially at point D on the graph, the added arousal from the same conceptual conflict, as in the previous example,

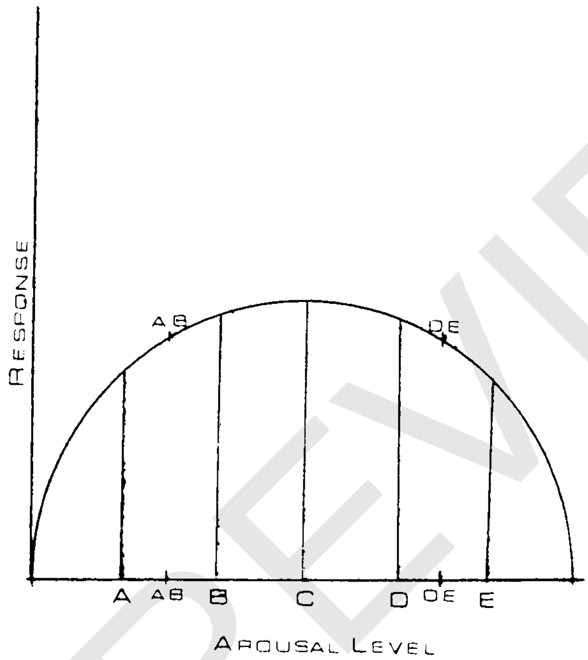

Figure 1. Response as a function of arousal level. Ordinate is any measure of response, e.g., strength, magnitude, probability, etc.

increases his arousal to point DE. If the person were to attempt to solve the conflict via epistemic behavior, it would entail moving to point E, i.e., increasing his arousal even higher, further above the optimum. It would be expected that a person who starts at point D will not engage in epistemic behavior. If the person withdraws from the situation, so that the conceptual conflict is no longer present, there is an immediate reduction in arousal, which, while it still may be above the optimum, is a movement toward that optimum. Thus, the arousal level is less than it would have been if epistemic behavior had been engaged in.

If the person were subjected to the effects of other variables that increase arousal at the same time that he faced a conceptual conflict, it is expected that the same conceptual conflict would be followed by different behavior, epistemic responses or withdrawal, depending on the contribution of the other sources of arousal to the resulting arousal level.

When more than one source of arousal is present, the effects will be cumulative. That is, the arousal from two sources will always be greater than from either source singly. The resultant of the joint influence of all the arousal producing factors in operation at any given time may be called the Overall Arousal Level (OAL).

An individual's characteristic level of arousal, i.e., that level of arousal that initially places a person on the arousal level axis, may be called Individual Arousal Level (IAL). Individual Arousal Level is determined by such factors as past history with conceptual conflicts, "fear of failure," general anxiety, etc. Other possible contributing sources of arousal at any moment are the collative variables

in the environment (CV), the psychophysical variables of the stimuli present (PV), and the ecological variables (EV), i.e., reactions to drive producing events. Increases of arousal from these sources of stimulation will add to or combine with the IAL to yield the OAL in a situation.

Curiosity is a source of arousal induced by the collative properties of the stimulus. The usual response to a conceptual conflict (a source of CV) is epistemic behavior, which ultimately leads to a reduction in arousal when the conflict is resolved. Epistemic behavior, because it often involves increasing the amount of unfamiliar stimulation (CV) to which a person is exposed, can produce an initial increase in arousal. Whether or not the increase in arousal generated by a conceptual conflict will be followed by epistemic behavior accompanied by a further increase in arousal or by withdrawal and an immediate reduction in arousal will be determined by the relationship of the OAL to the optimum. An OAL below the optimum favors epistemic behavior. Epistemic responses should be stronger as OAL moves towards the optimum level of arousal. An OAL above the optimum will result in a reduction in the tendency to, or failure to, engage in epistemic behavior. The same amount of conceptual conflict, then, can lead to different behavior depending on the results of the other arousal producing factors on OAL, i.e., whether the resulting OAL is above or below the optimum.

In general, individuals with a high IAL will differ in their response to added arousal from those with low IAL. Those with low IAL are assumed to generally operate below their optimum. Added arousal from a conceptual conflict will not increase OAL above the optimum for low IAL individuals and the prediction, based on the arousal-behavior

function (Fig. 1) is that epistemic behavior will result. Given a certain degree of conceptual conflict (and, hence, a certain amount of CV from this source) and an IAL sufficiently low, arousal added from still another source, e.g., an ecological variable (EV) will lead to an increase in epistemic behavior, provided that the arousal generated by EV does not push OAL above the optimum. Continued increase in arousal arising from EV will eventually lead to an OAL above the optimum and epistemic responses will decrease or cease, and the person will withdraw from the conceptual conflict. Persons with a high IAL, who operate close to or at their optimum level, will also respond to added arousal as predicted by the arousal-behavior function; i.e., small increments of added arousal will increase OAL to the point where maximum efficiency is expected, and then a continued increase in arousal will lead to a decrease in epistemic behavior. The amount of added arousal necessary to produce a decrease in epistemic responses in high IAL people will be less than that needed to produce such a decrement in low IAL people.

The present study attempted to extend the theoretical ideas generated from research on exploratory behavior and the pioneer work with humans to deal with human information seeking behavior, i.e., epistemic behavior. The study dealt with variations in external stimulation, both CV and EV, and in the characteristic arousal level of the person. It also examined the effects of the combination of these variables on the epistemic behavior of the individual.

The individual's characteristic level of arousal (IAL) was measured with a questionnaire describing an individual's level of anxiety in situations similar to an experiment (The Mandler-Sarason Test Anxiety Scale). Collative arousal (CV) was produced by presenting S with a

problem that he thought could be solved by gathering additional information. Ecological variability (EV), a source of arousal other than that characteristic of S, and other than arousal generated by CV, was produced by electric shock determined by each S's reaction to the shock. A questionnaire designed to measure the amount of time an individual spends in "epistemic activity," and the amount of time engaged in activities similar to the experimental test was also administered to all Ss.

High IAL and low IAL Ss were given five problems to work on in each of two experimental sessions. During each session, they received added arousal from electric shock. Half of the Ss in each IAL group received a low level of shock during both sessions, the other half received a low level of shock during the first session and a high level of shock during the second session. The shock was administered at random intervals throughout the session, and Ss could not respond so as to decrease or avoid shock presentation.

Hypotheses

The study was based on two premises:

A. That the level of arousal is a resultant of all the arousal producing events in operation at any given time; and,

B. That the tendency to engage in epistemic behavior is a curvilinear function of arousal. This function is described as an inverted U-shaped curve.

The validity of these premises was assessed indirectly through testing the following general and specific hypotheses:

General Hypothesis--The amount of epistemic behavior induced by a conceptual conflict, other things being equal, is dependent upon the presence of other sources of arousal.

Specific Hypothesis 1--Individuals who characteristically operate under a low level of arousal (IAL) will show less tendency to engage in epistemic behavior than those individuals who characteristically operate under High IAL, given the same conceptual conflict and low EV arousal.

Specific Hypothesis 2--Individuals with Low IAL will react to a given conceptual conflict with more epistemic behavior under higher EV than under low EV, while individuals with High IAL will react to the same conceptual conflict with less epistemic responses under higher EV arousal than under low EV arousal conditions.

METHOD

Subjects

All students in the introductory Psychology Classes at the University of Nebraska were administered the Mandler-Sarason Test Anxiety Scale (MSTAS) (Mandler and Sarason, 1952) as a measure of IAL. The MSTAS asks Ss to describe their responses to situations similar to the experimental session, thus, giving a measure of the IAL of all potential Ss (Sarason and Gordon, 1953). The Scale was prepared for computer scoring and data from males and females were scored separately. (See Appendix I for details of administration, scoring, and the computer program.)

From the total group of males tested on the MSTAS (N=411), 40 Ss were chosen at random from those scoring in the top 25% of the distribution, and 40 Ss in the bottom 25% of the distribution of the Scale, a total of 80 Ss. The Ss at the high end of the scale were designated as having a High Initial Arousal Level (HIAL) and those in the low end as having a Low Initial Arousal Level (LIAL). The Ss chosen were sent the following letter:

Department of Psychology

Mr. ____________,

You have been selected from the students registered for Psychology 70 to take part in a psychological experiment. The names of all students were put in a pool and a group was drawn randomly. This procedure was used because random samples are important in experimental work.

After you have taken part in this experiment you will have completely satisfied the course requirement, or have gained two extra credits in those courses where extra credit is given. That is, this experiment will count for two participations. Please do not sign up for any other experiment at this time. If you wish to take part in more experiments than required, you will have the opportunity to do so later in the semester.

The experiment will be run in two 1-hour sessions and every

effort will be made to fit the sessions into your schedule. The days and times that the experiment will be taking place are listed at the end of this letter, and the sooner you see me to arrange your sessions, the more sure you are of getting your first choice of times.

Indicate below the hours which would be most convenient for you, and your telephone number. You will be contacted for a short appointment during which the nature of the experiment will be explained and the times of the sessions will be scheduled.

Please fill in the information below and then return this letter to the Psychology department office, Room 220, Social Science Building.

Your cooperation will be of substantial assistance to me and will be greatly appreciated.

Marc Kessler
Ph.D. Candidate
Department of Psychology

Telephone Number ________
Preferred times, if you have any (indicate first and second choices).
Monday evening _____
Tuesday evening _____
Wednesday afternoon _____ evening _____
Thursday morning _____ afternoon _____ evening _____
Friday morning _____ afternoon _____ evening _____
Saturday morning _____

The Ss were then contacted and a short interview was arranged at which each Ss was told the following, with only slight deviations to allow for a conversational tone:

"As I've mentioned in the letter, I've chosen a group of subjects at random from the Psychology 70 classes to take part in my experiment. Random samples are necessary in order to make certain kinds of generalizations about the experiment.

"The experiment itself involves the use of mild, non-harmful electric shock; and, since it does, I'm giving everyone the opportunity not to take part, if he wants to. It's up to you. The only question I have is, 'Do you have a heart condition?'."

Any questions were answered as fully as possible, except that questions as to the purpose of the experiment were deferred to the end of S's participation in the experiment. Out of 110 original contact letters, 89 (79.4%) were returned. Of 52 letters sent to LIAL Ss, 41 were returned (78.8%). Of 60 letters sent to HIAL Ss, 48 were returned (80%). (The

extra Ss were used to replace Ss dropped from the experiment, or as Ss in a post-experimental task.) Appointments for two experimental sessions were arranged.

Experimental Variables

Experimental task, (collative variation). The experimental task presented Ss with a conceptual conflict, an unsolved problem, which could be resolved by epistemic behavior, i.e., seeking further information. The S's persistence in seeking solutions to non-soluable items was used to measure his tendency to engage in epistemic behavior. Persistence on non-soluable tasks was assumed to be a more accurate measure of S's epistemic curiosity than persistence on soluable tasks, since the time spent on the latter could also be determined by factors such as S's ability, knowledge, etc. On non-soluable tasks, when S does not know if there is a solution, the amount of time S spends depends presumably on his curiosity.

The experimental task had the form of a set of cryptograms except that the S had more ready access to the solution than in a usual set of cryptograms. That is, if S worked on an item long enough, he could, when a solution was available, obtain the solution by reorganizing the information given.

Each item was composed of a phrase or sentence with missing letters or groups of letters. In place of the missing elements were numbers which referred to a list of CVC nonsense syllables. Each number referred to one CVC, and one of the letters of the CVC was the missing letter that the number replaced. (See Appendix II for a copy of all items used, the list of CVC's, and the solutions.)

CVC's with low association values were taken from Hilgard's list

(Hilgard, 1951, p. 545). There were four different CVC's for each letter of the alphabet and the reference numbers were assigned at random. The same CVC did not appear twice in the same item.

The time Ss spent in seeking solutions to critical items, i.e., those items with no solution, was the principle experimental measure. The time S spent on soluable items was used as a baseline to assess S's characteristic problem solving speed, and a ratio between non-soluable and soluable time was used for statistical analysis.

Two sets of five items were prepared on the basis of the comparability of items. Pretesting of the list provided data about the time spent on the items, difficulty of the items, and similarity of the forms of the items. Two of the five items in each list had no solution and of the other three, one was solved by 90-95% of pretest Ss, one solved by 65-75%, and one solved by 50%.

Shock, (ecological variation). Two levels of randomly administered shock were delivered by a constant current, 0-10 ma. stimulator through copper finger-tip electrodes strapped to the first and third finger of S's non-preferred hand. The stimulator was wired to allow presentation of shock by E as well as randomly administered shock by a microswitch mounted over a film strip driven by a constant speed motor. (See Figure 2 for the wiring diagram.) This mechanism presented random interval shocks of 1 sec. duration. The interval had a range of 2-499 sec. with an average interval of 90 sec.

The level of shock to be administered was determined by a procedure developed by Schneider and Baker (1958) and modified by Sonderegger (1965). Each S's rating of the unpleasantness of shock was used to select a shock intensity for a high level of arousal and a low level of