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AROUSAL LEVEL, ADAPTATION LEVEL THEORY, AND PARTIAL REINFORCEMENT

by

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INTRODUCTION

This study is designed to investigate the effect of partial reinforcement on arousal level. The major hypothesis is that arousal level will change if the schedule of reinforcement of an operant response is changed. It is also hypothesized that the kind of arousal level change that occurs can best be accounted for by Helson's (1964) Adaptation Level Theory, and Amsel's (1958) Frustrative Non-Reward Theory.

The independent variables are partial reinforcement during fifty acquisition training trials, and no reinforcement (extinction) for fifty subsequent trials. The dependent variable is arousal change measured by changes in the galvanic skin response (GSR).

The independent variable partial reinforcement is a training procedure in which the reinforcement occurs on only a fraction of trials. It is generally agreed to be the type of reinforcement most commonly encountered by human beings, from infancy to death in almost all learning situations (Dollard and Miller, 1950; Deese, 1958). Partial reinforcement is certainly involved in personality development, inter-personal relationships, the development and maintenance of social institutions, as well as the typical school situation (Dollard and Miller, 1950). It is utilized in this study precisely because it is such an important environmental factor.

In psychology it has been known for a long time that partially reinforced responses are the more resistant to extinction than continuously reinforced responses (Lewis, 1960). Many variables have been investigated in relation to partial reinforcement, but its relationship with arousal level has never been investigated systematically.

The dependent variable arousal has been defined as changes in peripheral and central physiological measures of the activity of the reticulo-thalamo-cortical brain system (Lindsley, 1970; Milner, 1970). The most common peripheral measures known to be structurally related to this brain system are the galvanic skin response (Lindsley, 1950) heart rate (Obrist, Webb, and Strutterer, 1970a, b) and changes in electroencephalograph (EEG) (Morruzi and Magoun, 1949).

HELSON'S ADAPTATION LEVEL THEORY

No study has been found that utilized the arousal response to determine whether an adaptation level is involved in the arousal response itself. Schonpflug (1966) demonstrated that arousal affected sensory adaptation levels, but did not investigate a parallel effect in the arousal response. Helson (1964, 1967) has used his theory to explain the effect of partial reinforcement on a learned response, but has not applied his theory to the arousal response.

Helson's Adaptation Level Theory was developed in sensation and perception. It is a theoretical explanation of the behavior of Ss when ranking stimuli varying along a physical dimension. The main requirement for the application of Helson's theory is that the stimulus to be presented to Ss vary along some objective dimension.

This study will treat partial reinforcement schedules as analogous to Helson's conception of the stimulus in his theory. Partial reinforcement varies along an objective dimension. The percent of reinforcement used can range from 0% to 100%. Further, it is known that S's operant response rates are differentially affected by partial reinforcement schedules (Lewis, 1960; Jenkins, and Stanley, 1950; Deese, 1958).

A task was chosen that has been used regularly to manipulate the partial reinforcement effect. This is the task presented by the Humphreys' board (Humphreys, 1939). The S is presented with two buttons to push and told that only one is correct. Typically, the Ss respond by probability matching the percentage of reinforcement in their number of correct responses rather than consistently pressing the "correct" button which would maximize the number of correct responses (Humphreys, 1939; Lewis, 1960).

It is predicted that the arousal response will be influenced by the schedules of reinforcement. This study's assumption is that Helson's (1964) Adaptation Level Theory can predict adaptation levels of arousal for Ss trained during acquisition under different percentages of reinforcement; and predict when a change in arousal will occur when extinction is introduced.

Helson has quantified his theory. The mathematical formula was not used in this study, but the theorems derived from the mathematical theory were. Helson's formula specifies a performance function as a weighted geometric mean of the value of the focal stimulus, the values of the preceding residual stimulus, and the values of the background stimuli (Helson, 1964).

The focal stimulus in Adaptation Level Theory is the objective value of the stimulus presented on each succeeding trial. In this study the focal stimulus is whether the S receives a signal that his response is correct on each trial.

The residual stimulus is defined by Helson as the objective value of the stimuli presented on all the previous trials. In this study the residual stimulus is the previous history of reinforcement or in other words the percentage of reinforcement received by the end of acquisition.

The background stimulus in Helson's theory is the objective value of the background against which the focal stimulus is presented. In this study the background was the same for all Ss in that they were tested all under the same environmental conditions.

Helson's formula predicts a curvilinear performance curve. The curve reaches a point beyond which there is no appreciable change in performance as along as the value of the focal stimulus presented is not greater than the weighted geometric mean of the three stimuli affecting performance; focal, residual, and background stimuli.

The Ss respond as if there were no difference in the values of the successive stimuli presented even though objectively the stimuli represent different values of the stimulus dimension. This part of the performance curve which represents essentially no change is defined as the adaptation level.

The adaptation level in the performance function would occur at different trials for Ss who have received different values of the stimulus (different residual stimuli) or for Ss who received the same values of the stimulus, but received them under different background conditions. Thus, in this study, Ss receiving different percentages of reinforcement during acquisition should reach an adaptation level of performance at different trial points.

Helson (1964) derived several theorems from his formula to predict under what conditions the response will change from the adaptation level. These theorems specify the extent to which the stimulus must be increased or decreased to result in a change in the adaptation level of a S's response.

The theorem that predicts whether a stimulus value will act to change an adaptation level in an upward direction was used to predict whether the arousal magnitude response would increase or not during extinction.

"The definition of adaptation level as a weighted geometric mean immediately implies that every stimulus displaces level (the previous adaptation level) more or less in its own direction, providing that counteracting residuals are not operative. If a stimulus is above level, the level is displaced upwards; if below level, downward; and if it coincides, it does not change level" (Helson, 1964, p. 61). This study predicts that extinction will or will not change an adaptation level in an upward direction depending upon the percentage of reinforcement received by the Ss during acquisition.

The performance function of interest in this study is arousal change. Helson's theory will be used to predict adaptation levels in the arousal response. Further, the trial at which adaptation begins in the arousal response should be different for different reinforcement groups. The Helson theorem will be used to predict the relative points during extinction that the arousal response will begin to increase in magnitude for the different reinforcement groups. Therefore, under different percents of partial reinforcement the arousal response should reach different adaptation levels at different trials if the arousal response operates according to Helson's Adaptation Level Theory.

The lower the percentage reinforcement the later the adaptation level in the response should occur, because more trials would be required for the residual stimulus to build up to the point where it would counteract the next reinforced trial. It would take more trials for the Ss to not discriminate a particular reinforced trial from their previously reinforced trials. Helson's theorems will be tested by the introduction of extinction. Extinction in this case is a stimulus with an objective value of zero. If the Ss were trained under a low percentage of reinforcement and had reached an adaptation level in their arousal response, the introduction of "extinction" should not disturb adaptation level until very late in the extinction trials because of the counteracting residuals from acquisition according to the previously stated theorem.

Under a high percentage of reinforcement during acquisition, given an adaptation level the introduction of "extinction" should result in an almost immediate change in arousal.

Under a moderate percentage of reinforcement during training, given an adaptation level, the introduction of "extinction" should result in a change in arousal that occurs later in the extinction trials than that for the Ss who had been trained under a high percentage of reinforcement, and before that for Ss who had been trained under a low percentage of reinforcement. The difference would occur because the residual stimuli would be different for each of the groups of Ss. Helson's Adaptation Level Theory hypothesizes the variables that determine whether a response performance curve will reach an adaptation level, and under what changes in those variables the response will deviate from an adaptation level.

Helson's theory was used by this study to predict the above characteristics of performance.

AMSEL'S FRUSTRATIVE NON-REWARD THEORY

This study used Amsel's (1958) theory to predict the magnitude of the arousal response. Amsel (1958) maintains that after a response has been rewarded a sufficient number of times permitting the development of anticipatory goal responses, non-reward will elicit a primary motivational condition, frustration. Some of the variables which appear to determine the occurrence and strength of frustration as a motivator are non-reward after training under reward conditions (Amsel and Roussel, 1952), and reduction in amount of reward (Bower, 1962).

Arousal has been used as a measure of the motivational construct "drive" (Hebb, 1955; Lindsley, 1957; Malmo, 1959). According to Brown and Farber (1951) the primary consequences of frustration are that it adds to the general drive level and thus functions like any other drive state, while it provides internal stimuli to which appropriate responses may be attached.

In this study it was predicted that the magnitude of the arousal response would differ for three different ratios of reinforcement. The task directions lead all the Ss to anticipate that one of the two responses will be reinforced. Therefore, Ss receiving 100% reinforcement during acquisition should experience little increase in frustration from trial to trial because they are receiving their anticipated reward. Therefore, a 100% group should show lesser amounts of arousal than would Ss receiving lower percentages of reinforcement.

As previously noted all Ss begin with the same anticipations of reward. Therefore, Ss receiving a low percentage of reinforcement from trial to trial should have a greater frustration response and hence a greater amount of arousal than Ss receiving a higher percentage of reinforcement.

A moderate percentage of reinforcement should result in moderate amounts of frustrative non-reward. Therefore, such a group should have moderate levels of arousal magnitude when compared to those obtained by a 100% group and a low percentage of reinforcement group.

With the introduction of extinction, frustration and anticipatory goal responses would be different for all three groups. The "frustration effect" of extinction should be greater for Ss receiving 100% reinforcement than for Ss receiving moderate or low percentages of reinforcement. Specifically, 100% reinforcement during acquisition should result in greater frustration effects on the arousal response during extinction followed by a medium reinforcement group and then a low reinforcement group.

Amsel's Frustrative Non-Reward Theory was used to predict the magnitude of the arousal response during acquisition and extinction. Helson's Adaptation Level Theory was used to predict that the arousal response would reach an adaptation level, and whether the arousal response would deviate from an adaptation level when extinction was introduced.

AROUSAL

The dependent variable under consideration in this study is arousal. Arousal was previously defined as changes in peripheral and central measures of the activity of the reticulo-thalamo-cortical brain system. Changes are reflected in all the peripheral and central measures by almost every known stimulus change (Berlyne, 1967; Lacey, 1967; Milner, 1970).

Changes also occur in these measures when there is no observable external behavioral indication that a stimulus has been effective (Lacey, Hagen, and Moss, 1963; Bruner and Postman, 1950). This pervasive association of arousal change with stimulus change has constituted a problem for theorists who have attempted to identify the motivational construct "drive" with changes in arousal (Berlyne, 1967; Lacey, 1967).

Arousal change has been theoretically identified with Hebb's (1955) motivational construct of "drive" as a non-specific energizer of behavior (Lindsley, 1957; Malmo, 1959). However, arousal change has been found to be associated with many stimuli not generally considered to be drive stimuli. "Arousal can be varied by novelty or surprisingness (Berlyne, 1960, 1961)." Stimulus intensity has been shown to influence the GSR, an arousal measure. Arousal change is associated with changes in Ss focus of attention (Berlyne, 1960).

Arousal apparently reflects any change in stimulation, and reflects internal changes in the organism not reflected in external observable behavior (Lacey, 1967).

The only study found utilizing partial reinforcement and arousal measures was done by Greene (1966). In this study the GSR was the dependent variable. The Ss were placed in a dark room. A light stimulus was presented contingently upon a GSR change. Three ratios of partial reinforcement were used. Greene found a difference affect only within the first 2 minutes after presentation of the light stimulus. He concluded that "...partial reinforcement influences the unelicited GSR in a fashion only remotely similar to its influence upon somatically mediated responses (Greene, 1966, p. 578)." Greene stated that "unelicited GSR can be differentially influenced by contingency of reinforcement (p. 578)." However, it is known that arousal change can be varied by novelty or surprisingness (Berlyne, 1960, 1961). The differential changes in arousal in the first 2 minutes could also be due to the difference in novelty or surprisingness of the light stimulus in a darkened room for the different reinforcement groups.

No other studies have been found which attempted to investigate the relationship between different reinforcement schedules and arousal.

Schonpflug (1966) investigated the relationship between ranking of stimuli, externally induced arousal and adaptation level. He found that the process of adaptation, the approach of stimuli ratings toward a neutral point (adaptation level) with repeated presentations was slower under conditions of higher as opposed to lower arousal. He also found that increased arousal affected judgments of stimuli ranks when <u>S</u>s were ranking magnitudes.

In 1967 after an extensive review of the arousal as "drive" literature, Berlyne concluded that it was impossible to identify arousal change with the motivational construct "drive" because of its pervasive association with stimuli change.

However, Berlyne (1960), Malmo (1959) and others have conceived of arousal as having an optimal level to which many performances are related (Berlyne, 1960, 1967). The theoretical problem can be resolved if one goes back to Hebb's original formulation of drive as a non-specific energizer of behavior. One can conceive of the organism as always being energized at some level and for different tasks different levels are appropriate. If one presents a novelty task a different level is appropriate than if one presents a learning task. This study uses an adaptation level model for arousal because adaptation level theory predicts many different adaptation levels. The specific adaptation level obtained is dependent upon the change in stimulus values in the situation. Arousal viewed from a combination of Helson's Adaptation Level Theory and Amsel's Frustrative Non-Reward Theory may have less difficulty than Berlyne's and Malmo's "optimal level" definition of arousal as "drive".

METHOD

Subjects

Forty-five introductory psychology students were used as Ss. They were randomly assigned to one of three reinforcement groups.

Apparatus

The apparatus for the learning task was a modified Humphreys board (Humphreys, 1939). The S sits in front of a board that has two buttons at the base directly below two red lights. Each button has a light above it. Above the red lights is a yellow light. The yellow light signals the beginning of a trial. When the trial is signalled, the S presses one of the buttons in front of him. He has been previously instructed to choose the one he thinks is correct. If he chooses incorrectly, no red light goes on and the yellow light goes on to indicate another trial. If he chooses correctly, the red light above the button goes on, if that trial is one to be reinforced. After reinforcement or none, the yellow light goes on again indicating a new trial. The E had a counter for each button to tally correct and incorrect trials; or the number of times each button was pushed. A trial sheet was set up for each S with the trials by number, a space for correct or incorrect responses, and whether the S should be reinforced on a trial if a correct response was given.

While engaged in this task, the Ss galvanic skin response (GSR) was continually monitored by a Marietta GSR. The recording paper records the deflection of the needle in terms of skin resistance. The recording paper is equal interval and reflects the exact change in ohms. The GSR was connected to the Humphreys board so that when a trial commenced it was recorded on the recording paper as well as whether the S responded by pushing one of the buttons. The electrode connected to the Marietta GSR was a U-shaped piece of plexiglass with two 3/8 inch silver discs at each end. It is shaped to be fastened on to the hand of a S. The electrode was hollowed out and filled with Grass Electrode Paste. This type of electrode eliminates the problem of random hand movements and electrode seepage (Brodsky, 1969).

Procedure

Three reinforcement conditions were selected, 100%, 50%, and 12%. The trials to be reinforced were randomly selected for the 50% and 12% conditions constituting variable ratio reinforcement.

The Ss were randomly assigned to one of the three groups when they entered the experimental room.

In the room where the experiment was run was a Humphreys board, and a Marietta GSR (previously described) side by side upon a table. The E sat behind the Humphreys board and the S sat in front of it.

Upon entering the room, the S was told that the E wished to monitor his GSR during the experiment. The electrode clamp was fastened on to the S's non-preferred hand. After making sure the S was comfortable, the S was instructed as follows:

"As you can see there is one red light above each button, and a yellow light above the red lights. When the yellow light goes on, you are to choose which red light you think will go on and press the button below it. If you are correct, the red light above the button you have chosen will go on, if incorrect, it will not go on and we will go on to the next trial. Are there any questions?" (Humphreys, 1939).

If the S had a question, the directions were repeated. Then the E seated herself behind the board and said, "Are you ready?" and the trials commenced. After the experiment, the S was given a paper describing the purpose of the experiment.

Only one red light and the button below it was used respectively for reinforcement for the correct response. In order to obviate a left or right response bias, the button that was to be correct for a S was randomly selected for all the Ss before the Ss were run. For any particular S the left or right button was previously determined to represent the correct response.

Each S received 50 acquisition trials followed immediately by 50 extinction trials. The independent variables were three ratios of reinforcement and acquisition versus extinction. The dependent variable under consideration was arousal magnitude.

Measurement

The arousal response was measured by a Marietta GSR using Brodsky's (1969) Arousal Interval Scale (AIS). With this scale each

S's base level of arousal recorded ohms resistance when seated and relaxed, is equated as zero. The numbers recorded reflect the amount of deflection from that zero on the equal interval recording paper of the Marietta GSR. The intervals reflect the exact amount of change in ohms resistance. All Ss were tested at approximately the same time of day, when wide awake to avoid any circadian rhythm effects.

HYPOTHESES

1. Arousal magnitude during the acquisition trials is an inverse function of the percentage of reinforcement during acquisition.
2. During acquisition the relation between arousal and percent reinforcement is curvilinear.
3. The trial at which adaptation begins during acquisition is an inverse function of percent reinforcement.
4. There is a direct relationship between the increase of arousal magnitude dueing extinction and the percentage of reinforcement during acquisition.
5. The trial at which arousal begins to increase in magnitude during extinction is an inverse linear function of percent reinforcement received during acquisition.

STATISTICAL MODEL

The data was analyzed by two trials by subjects analyses of variance. Table 1 contains the main analysis. This is an analysis of variance of the arousal magnitude across trials during acquisition and extinction. It is a trials by subjects analysis of variance with one between-groups variable (3 percentages of reinforcement) and two within-Ss variables, trials and acquisiton-extinction.

There were 45 Ss with 15 Ss in each group. The dependent variable arousal magnitude represented by AIS scores for each S were summed across 5 trials resulting in 10 blocked trials for acquisition and ten for extinction, a total of twenty blocked trials.

A linear trend analysis was computed within the third order interaction term Acquisition-Extinction x Reinforcement x Trials in order to determine if the AIS scores of the three reinforcement groups were linear during extinction. This is the factor Extinction x Reinforcement x Trials linear. The linear trend analysis computed trends only for the extinction data. The acquisition data was given zero weights. Two orthogonal comparisons were computed within the trend analysis in order to determine whether the linear trends of the three groups during extinction were significantly different. These are the factors Extinction x Reinforcement R_1 vs R_2 R_3 x Trials linear and R_2 vs R_3 x Trials linear. The acquisition data was again given zero weights in order to compare the differences between the three groups arousal magnitude during extinction. Using only the extinction data R_1 represents the orthogonally weighted linear trends of the 12% group, R_2 represents the orthogonally weighted linear trends of the 50% group, and similarly, R_3 represents the orthogonally weighted linear trends of the 100% group.

The second trials by subjects analysis of variance (Table 2) utilized the acquisition data from 45 Ss in groups of 15 Ss. The AIS scores on each acquisition trial were summed into blocks of 5 resulting in 10 trial blocks. This analysis was done to obtain the variances associated with acquisition arousal magnitude in order to calculate a trend analysis and an orthogonal comparison. Linear and quadratic trend analyses were computed within the second order interaction term Reinforcement x Trials in order to determine if the AIS scores of the three reinforcement groups were linear or quadratic (curvilinear) during acquisition. These are the factor R x Trials linear and R x Trials quadratic. Two orthogonal comparisons were computed within the linear trend analysis in order to determine whether the linear trends of the three groups were significantly different during acquisition. These are the factors R_1 vs R_2 R_3 x Trials linear and R_2 vs R_3 x Trials linear. R_1 again represents the orthogonally weighted linear trend of the 12% group, similarly, R_2 is the 50% group and again R_3 is the 100% group.

RESULTS

Hypothesis 1 was tested by the linear trend orthogonal comparisons R_1 vs R_2 R_3 x Trials linear and R_2 vs R_3 x Trials linear (Table 2). These factors were significant, meaning that the arousal magnitudes of the three reinforcement groups were linear and significantly different during acquisition. An inspection of Figure 3 will confirm that the 12% group had the highest levels of arousal followed by the 50% group and then the 100% group with the lowest level.

The quadratic trend analysis R x Trials quadratic in Table 2 was a test of hypothesis 2. This factor did not reach significance. Therefore, the AIS scores during acquisition could not be described as curvilinear. The linear trend analysis R x Trials linear was significant. Therefore, linear functions best describe the AIS scores during acquisition.

The trial at which the adaptation level begins during acquisition, Hypothesis 3 can best be determined by inspection of Figure 3. The 100% group's arousal magnitude function is linear with zero slope from trial 5 as is that of the 50% group. The 100% and 50% groups' arousal functions do not appear to have an initiation point of the adaptation level. The 12% group, on the other hand, appears to have initiated its adaptation level between trial 50 of acquisition and trial 5 of extinction. Since the trial point at which adaptation began for the 50% and 100% groups cannot be determined, hypothesis 3 cannot be tested by this data.

Hypothesis 4 was tested by the linear trend orthogonal comparisons Extinction x Reinforcement R_1 vs R_2 R_3 trials linear and Extinction x Reinforcement R_2 vs R_3 trials linear (Table 1). The first factor compared the linear arousal functions of the 12% group during extinction with the combined functions of the 50% and 100% groups. The second factor compares the linear functions during extinction of the 50% group with those of the 100% group. The acquisition data was set at zero in order to make these comparisons as previously described. Both of the factors were significant indicating that the linear trends of the three groups were significantly different in magnitude of arousal during extinction.

Further inspection of Figures 3 and 4 show that higher arousal magnitudes were recorded during extinction. Comparison of Figures 3 and 4 shows that arousal magnitude did not change very much, if at all, for the 12% group, but changes occurred in the responses of the other two groups. The 100% group changed from a mean AIS level of 30 from trial 10 through trial 50, during acquisition to 55 by the 5th trial of extinction. The 50% group mean AIS scores ranged from 55 to 70 during acquisition. They jumped from a mean score of 70 at trial 50 of acquisition to a high of 105 during extinction.

In terms of relative change in arousal magnitude from acquisition to extinction, the relationship was direct between the increase of arousal magnitude during extinction and the percentage of reinforcement during acquisition.

Hypothesis 5, can be confirmed by inspection of Figure 4. The trial points at which arousal magnitude began to increase during extinction is in the order predicted. Figure 4 shows that the increase in arousal magnitude for the 100% group during extinction was immediate and large. The change for the 50% group was slow, only by trial 20 can a large progressive change be discerned. The arousal magnitude of the 12% group does not change appreciably for the 50 trials of extinction.

It appears from inspection of Figure 4 that the trial at which arousal magnitude begins to increase during extinction is an inverse linear function of percent reinforcement received during acquisition.

DISCUSSION

The hypotheses drawn from Amsel's (1958) Frustrative Non-Reward Theory; hypotheses 1 and 4 received strong support from the results of this study. Each ratio of reinforcement did result in a different magnitude of the arousal response during acquisition and extinction. During acquisition the 12% group recorded the highest total arousal magnitude followed in order by the 50% and 100% group. The relative change in magnitude recorded was in the order predicted during extinction. The 12% group had essentially no change in arousal magnitude from the end of acquisition to the end of extinction. The 100% group showed the greatest relative increase in arousal magnitude followed by the 50% group.

The hypotheses 2 and 3 drawn from Helson's theory received partial support. It can be said that the linear parellel arousal functions during acquisition of the 100% and 50% groups could represent adaptation levels. Schonpflug (1966) defines the adaptation level as the approach of the function towards a neutral point.

The 12% group's arousal function does approach a neutral point and maintains a parallel linear function during extinction. The difficulty is in the word approach or in Helson's (1964) adaptation level formula. That formula defines a curvilinear function. As can be seen by the results in Tables 1 and 2 the trends are best described as linear and parallel. If there was an approach to a neutral point by the 100% and 50% groups, it might have been obscured by the summing of the scores into trial blocks. However, if that is the case, it could not have been a very significant effect. It appears that arousal magnitude adapts but not as Adaptation Level Theory predicts.

On the other hand, the hypotheses drawn from Helson's theorems, hypothesis 5, was confirmed. The 12% group maintained what looks like an adaptation throughout extinction. Extinction as a change from the conditions during acquisition could be said to have had no effect on the 12% group. The 100% group immediately began to show a large increase in arousal magnitude at the beginning of extinction. The 50% group did not show an appreciable change in arousal magnitude until trial 20 of extinction, considerably later than the rise shown by the 100% group.

Therefore, this study partially supports Helson's Adaptation Level Theory as a model for the functioning of the arousal system's increases in magnitude.

On the other hand, the hypothesis drawn from Helson's theorems, hypothesis 5, was confirmed. The 100% group immediately began to show a large increase in arousal magnitude at the beginning of extinction. The 50% group did not show an appreciable change in arousal magnitude until trial 20 of extinction, considerably later than the trial at which the change occurred for the 100% group. The 100% group showed a large increase in arousal magnitude between trial 50 of acquisition and trial 5 of extinction. The 12% group did not change it's response during extinction. It's arousal magnitude remained essentially the same during 50 trials of extinction. They maintained an adaptation level throughout extinction. Extinction as a change from the conditions during acquisition could be said to have had no effect on the 12% group. Therefore, this study partially supports Helson's Adaptation Level Theory asaa model for the functioning of the arousal system's increases in magnitude.

Finally, reinforcement controlled arousal magnitude within the ranges of arousal magnitudes obtained in this study. However, this study utilized only three percentages of reinforcement, and a very simple task. The task was obviously a "chance" situation, therefore, the whole dimension of arousal was not engaged and it reflected only the arousal response given to a simple "chance" task. Selye (1956) found that for Ss under high levels of stress for a long period of time, little or no variability in arousal magnitude is shown. His work would indicate that the relationship between arousal and reinforcement found here may not hold for extremely stressful situations that occur over long periods. The variability of the arousal system is apparently restricted by sustained stress.

The findings from this study of different arousal adaptation levels could, perhaps, with further research, provide an explanation of Selye's findings. A very high arousal adaptation level would need a very large change in stimulus value in order to cause a change in arousal magnitude. Analogous to this in this study is that the 12% group never did change from adaptation level during extinction. The constriction of variability in arousal found in the stress syndrome could possibly be conceived of as an abnormally high adaptation level of the arousal response which does not respond easily to changes in stimulus values. However, it would be necessary to further investigate the nature of the functioning of the arousal response before the effects of very high adaptation levels could be ascertained. The unchanging adaptation level of the 12% group could conceivably only hold for the conditions of this study. For example, the 12% group might have shown a change in arousal magnitude if there were more trials during extinction.

To summarize, it would appear that the Frustrative Non-Reward Theory accounts for the relationship between magnitude of arousal and reinforcement in this study in a straightforward and consistent manner. The arousal magnitude response appears to have adapted in that linear parallel functions occurred in the responses of all three groups but the process of adaptation was not that predicted by Helson's theory. Linear parallel functions were found for all three groups but the 50% and 100% groups appeared to initiate an adaptation to the reinforcement percentage received immediately. The trial point for beginning of the adaptation level could only be determined for the 12% group and it was much later than expected.

Hypothesis 5, based on Helson's theorem, was confirmed. The 12% group showed no deviation from adaptation level during extinction and the 100% group showed an increased arousal magnitude first, followed by the 50% group.

Conclusion

Amsel's Frustrative Non-Reward Theory best predicted the effect of different percentages of reinforcement on arousal magnitude. Helson's Adaptation Level Theory predicted curvilinear functions of arousal magnitude during acquistion. Linear parallel functions were found for the 50% and 100% groups; a linear parallel function occurred in the 12% group's response during extinction. Therefore, the arousal response appears to have adapted but the process of adaptation was not predicted by Helson's theory. On the other hand, the hypothesis derived from Helson's theorem was confirmed during extinction.

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TABLE 1

Summary of the Analyses of Variance of the Arousal Interval Scores (AIS) for three Percentages of Reinforcement (R), and Acquisition (A) Extinction (E) Trials (T)

SOURCE TABLE

	df	SS	MS	F
Total	899	1,946,855.00		
Between				
Reinforcement	2	145,192.56	72,596.25	4.420*
Error (SW/R)	42	689,798.50	16,423.77	
Within				
Acquisition-Extinction	1	241,933.37	241,933.37	31.09***
A-E x Reinforcement	2	1,989.49	994.74	0.12
Error (A-E x SW/R)	42	326,801.68	7,708.99	
Trials	9	39,616.79	4,401.86	9.132***
Trials linear	1	39,236.83	39,236.83	16.85***
Residual	8	379.96	47.43	.18
Trials x Reinforcement	18	6,285.64	349.20	.724
Trials linear x Reinforcement	2	5,808.73	2,904.37	1.21
Residual x Reinforcement	16	476.91	29.80	.11
Trials Error (Trials x SW/R)	378	182,208.31	482.03	
Trials linear x SW/R	42	100,022.82	2,386.38	
Trials residual x SW/R	336	84,461.93	251.37	
Acquisition-Extinction x Trials	9	6,712.14	745.79	1.08
A-E x Trials linear	1	2,476.00	2,476.00	1.20
A-E x Trials residual	8	4,236.14	529.51	.92
Acquisition-Extinction x Reinforcement x Trials	18	26,619.09	1,478.83	1.99**
Extinction x Reinforcement x Trials linear	2	20,900.99	10,450.49	7.20**
Extinction x Reinforcement (R_1) vs. R_2R_3 Trials linear	1	12,049.78	12,049.75	6.01*
Extinction x Reinforcement R_2 vs. R_3 Trials linear	1	8,930.00	8,930.00	4.47*
Acquisition-Extinction x Reinforcement x Trials residual	8	5,718.10	714.76	1.24
Acquisition-Extinction x Trials Error (SW/R)	378	279,701.00	739.94	
E x Trials linear x SW/R	42	84,152.02	2,003.61	
E x Trials residual x SW/R	336	193,272.54	575.21	

*$p < .05$.

**$p < .01$.

***$p < .001$.

TABLE 2

Summary of the Analyses of Variance of the Arousal Interval Scores (AIS) for three Percentages of Reinforcement (R), and Acquisition Trials (T)

SOURCE TABLE

	df	SS	MS	F
Total	449	666,141.18		
Between				
Reinforcement	2	84,334.75	42,167.37	6.08*
Error	42	280,761.00	6,684.	
Within				
Trials	9	31,636.61	3,514.51	5.38*
Trials Linear	1	30,037.00	30,037.00	46.05**
Trials quadratic	1	623.80	323.80	.95
Trials Residual	7	975.81	139.40	.01
Reinforcement x Trials	18	22,902.54	1,272.36	1.95*
R x Trials linear	2	18,544.84	9,272.50	22.96**
R x Trials quadratic	2	1,153.71	576.85	1.12
R_1 vs R_2R_3 x Trials linear	1	6,118.69	6,118.69	15.15**
R_2 vs R_3 x Trials linear	1	7,836.00	7,836.00	19.40**
R x T residual	14	2,203.99	157.42	.02
Trials Error	378	246,512.68	652.149	
Trials linear x SW/R	42	16,957.96	403.75	
Trials quadratic x SW/R	42	21,488.76	511.63	
Reinforcement x Trials residual	294	208,065.96	707.70	

*$p < .01$.

**$p < .001$.

TABLE 3

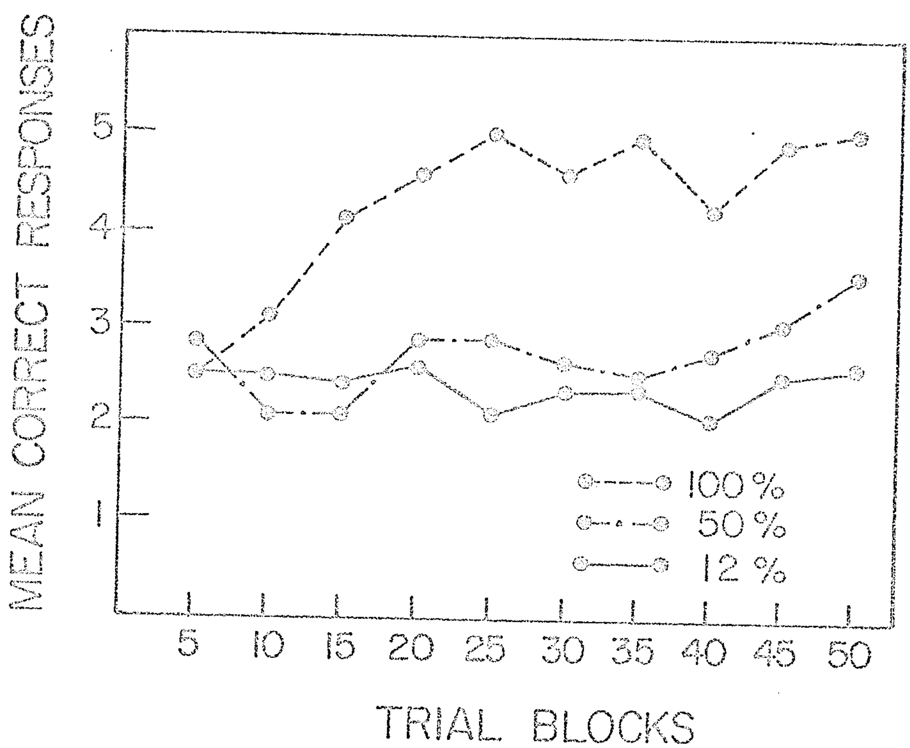
Summary of the Analyses of Variance of the Number of Correct Responses for three Percentages of Reinforcement, and Acquisition-Extinction Trials

	df	SS	MS	F
Total	699			
Between				
Reinforcement	2	280	140	25.45***
Error (SW/R)	42	232	5.5	
Within				
Acquisition-Extinction	1	44	44	27.5***
A-E x Reinforcement	2	106	53	33.13***
Error (A-E x SW/R)	42	67	1.6	
Trials	9	15	1.66	55.33***
Trials x Reinforcement	18	37	2	66.66***
Trials Error (Trials x SW/R)	378	13	.03	
Acquisition-Extinction x Trials	9	617	69	862.5***
Acquisition-Extinction x Trials x Reinforcement	18	18	1.0	21.00***
Acquisition-Extinction x Trials Error (SW/R)	378	31	.08	

TABLE 4

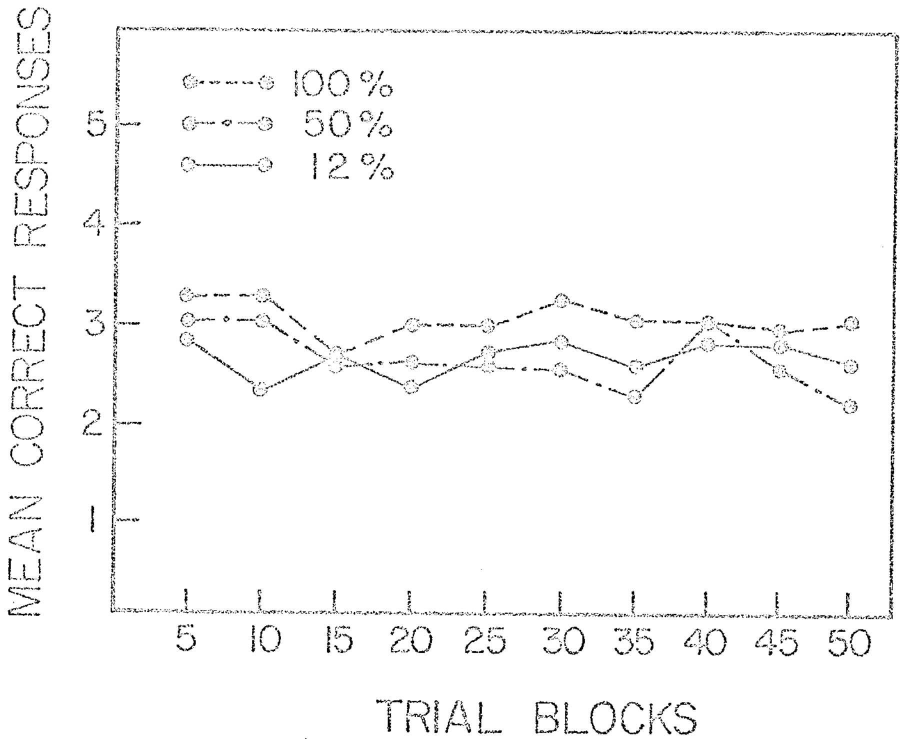
The Number of Correct Responses Actually Reinforced for Each Experimental Group During Acquisition

Ratio Schedule	12%	50%	100%
Mean Ratio of Reinforcement Received	6%	26.6%	90%
Mean Reinforcement Received over 50 Acquisition Trials	2.8	13.3	45
Standard Deviation	.905	4.09	1.41
Range	2 to 5	8 to 18	41 to 49



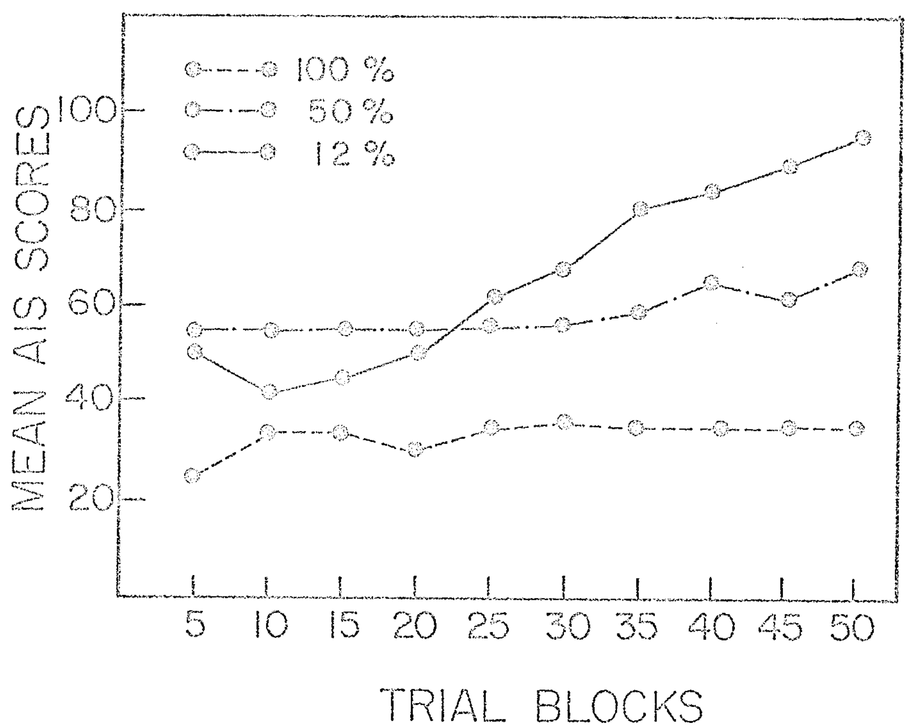
MEAN CORRECT RESPONSES DURING ACQUISITION BY REINFORCEMENT GROUPS

Figure I



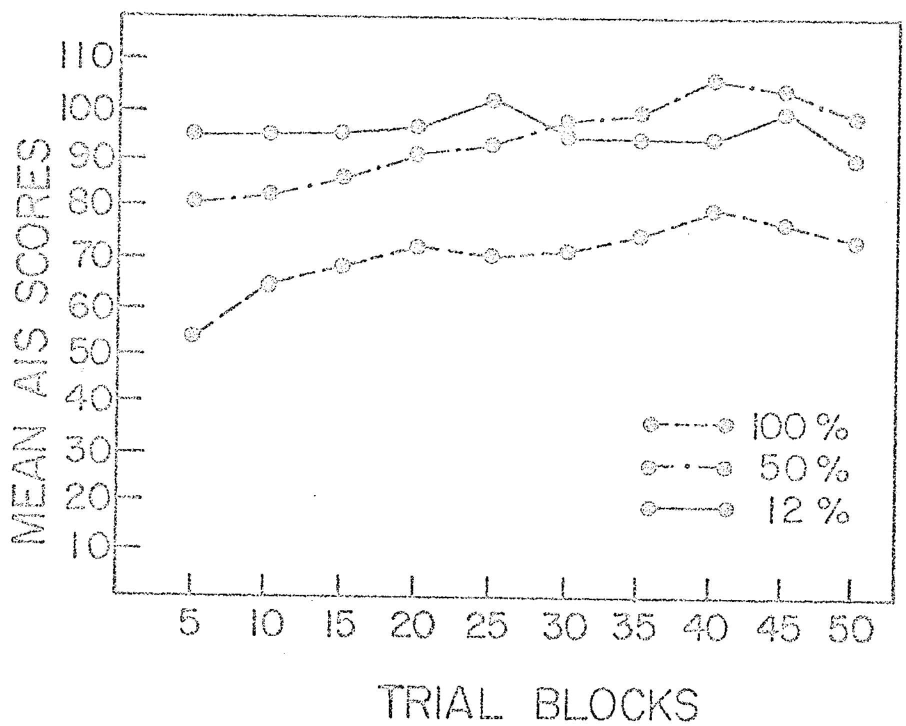
MEAN CORRECT RESPONSES DURING
EXTINCTION BY REINFORCEMENT GROUP

Figure 2



MEAN AROUSAL SCORES DURING
ACQUISITION BY REINFORCEMENT GROUP

Figure 3



MEAN AROUSAL SCORES DURING EXTINCTION BY REINFORCEMENT GROUP

Figure 4