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SOME APPLICATIONS OF ADAPTATION-LEVEL THEORY TO AVERSIVE BEHAVIOR[1]

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Adaptation-level (AL) theory qualitatively accounts for several phenomena in the area of aversive behavior: (*a*) adaptation and contrast effects, (*b*) the attenuation of an aversive event's effectiveness found when its intensity is gradually increased, and (*c*) the correspondence of performance to the average reinforcement intensity when the reinforcers vary in intensity. Perceptual effects are sometimes overshadowed by conditioning processes, especially in studies where shock is given before a learning task. It is concluded that AL theory is useful in understanding aversive behavior, although parametric investigations and subsequent quantitative applications of the model are needed.

According to adaptation-level (AL) theory, the sensation aroused by any stimulus is determined by the difference between it and an internal referent. This referent, the AL, is produced by stimulus pooling, and the best estimate of it is usually a weighted log mean of present and previously presented stimuli (Helson, 1964). The AL is, therefore, the perceptual neutral or indifference point, since apparent stimulus magnitude decreases as stimuli approach AL. Stimuli above AL evoke one kind of judgment or response, and stimuli below it evoke the opposite response. For example, if subjects are judging a series of weights, weights above AL are reported as heavy, and weights below it as light.

To apply AL theory to phenomena of learning and reinforcement it must be assumed that the important properties of reinforcers are their stimulus properties, and that the apparent magnitude of a reinforcement is determined by its relation to a standard formed by the pooled effects of previous reinforcements. The Bevan-Adamson reinforcement model (Bevan, 1963, 1966) considers learning from an AL framework. All reinforcers, regardless of their quality, are asserted to lie on an affective continuum with an indifference point separating pleasantness from unpleasantness. The model assumes that reinforcement effectiveness is a joint function of the organism's "tension" level, and the distance of the reinforcer from the organism's AL or indifference point on the affective continuum. Tension level is a construct defined by deprivation conditions and other drive-inducing operations; it is assumed to have a curvilinear relation with performance.

Although AL theory can be applied to reinforcement phenomena in general, the present paper is limited to a review of learning experiments that involve aversive stimuli, that is, stimuli that an organism will escape. Very often, however, stimuli are simply assumed to be aversive, especially if similar stimuli have been shown to meet the escape criterion. It is clear that aversiveness is a relative quality since an organism will escape one condition only if it has a less aversive condition to escape to.

Shock as a Scalable Stimulus

If reinforcers are to be usefully conceived of as stimuli, it must be shown that perceptual phenomena, demonstrated in frame-of-reference psychophysics, can be shown with reinforcers. There is evidence that the stimulus properties of shock affect its reinforcement value: Boe and Church (1967), using rats in a bar-pressing situation, have found that the amount of suppression produced per shock punishment for shocks of various intensities was a power function which closely resembled the relation found between amount of current and subjective judgment of intensity in human subjects. Moreover, perceptual phe-

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nomena predicted by AL theory can be obtained using shock as a stimulus. Bevan and Adamson (1960) had human subjects rate the intensity of five intensities of shock on a scale ranging from very weak to very strong. The relative frequency with which each intensity was presented was varied over 3 successive days. On one day each intensity was presented 20 times; on another, the distribution of intensities was made positively skewed by presenting the weaker stimuli more frequently; on the remaining day an even more positively skewed distribution was given. Each subject experienced each of the distributions, the order of their presentation being varied across subjects. The indifference point, the median category judgment, was highest for the rectilinear series and lowest for the most skewed, a familiar finding in perception experiments. This result is predicted by AL theory, because the geometric mean of the stimuli is lower the more positively skewed the distribution.

Pooling

Any extension of AL theory to reinforcement requires that reinforcers pool to form a level. Several experiments employing aversive stimuli and offering direct or indirect evidence for a pooling process will be reviewed to support this extension.

Passey and Sekyra (1964) varied air-puff intensity within subjects in a delayed eyelid conditioning experiment. There were seven groups designated by the unconditioned stimulus (US) they received: (*a*) constant 6.5 psi, (*b*) variable with mean of 6.5 and geometric mean of 5.5, (*c*) constant 5.5, (*d*) variable with mean of 6.5 and geometric mean of 4.5, (*e*) constant 4.5, (*f*) variable with mean of 6.5 and geometric mean of 3.6, and (*g*) constant 3.6. A significant difference appeared between groups whenever the geometric means of the USs they received differed by more than 2 psi and not otherwise. These data suggest that USs pool in classical conditioning, and that the best estimate of pooled level is the geometric mean.

Bevan and Adamson (1960) varied punishment intensity for incorrect responses in a bolthead stylus maze task. Three groups of college students all received five intensities of shock but differed as to the proportion of times each series member was presented to them: Group A received a positively skewed distribution with mean equal to 2.0 milliamperes (ma), Group B experienced a negatively skewed distribution with a mean of 2.6 ma, and Group C was given a symmetrical distribution with the mean equal to 2.3 ma. A curvilinear relation was obtained; the 2.0 ma mean group performed the poorest, and the 2.6 ma mean intensity group performed more poorly than the other two groups. There was no difference between the group with a mean of 2.3 and the constant 2.3 ma group in accordance with a pooling notion.

A compelling example of the pervasive influence of AL in determining an organism's response to aversive control procedures can be found in an excellent study of eighth-grade boys by Crandall, Good, and Crandall (1964). They assessed the pooled effects of prior reinforcements on each boy by asking how well he expected to do on an angle-matching task before the study started. The boys were then given the task twice and their expectancy of success was obtained after each time. The design was a $2 \times 2 \times 2$ factorial where the variables were: (*a*) high or low initial expectancy for success, (*b*) approving or disapproving verbalization from the experimenter during the first task, and (*c*) no experimenter present or a nonreacting experimenter in the second task. Subjects could not tell how well they actually did on the task so that the experimenter provided the only feedback. The results are those that would be expected from AL theory. Boys with high initial expectancy for success (AL) dropped their estimates more than low-expectancy subjects if they received punishment. Low-expectancy subjects were more affected by approval than high-expectancy subjects. Since an interpretation in terms of ceiling and floor effects was ruled out statistically, these data indicate that subjects have an internal standard and that reinforcements farther from it are more effective. The most interesting finding was that subjects who had received verbal reward in the first task dropped their expectancies after performing with a passive experimenter, whereas subjects that had punishment raised theirs. It appears that AL determines whether silence appears as reward or punishment.

Further indirect evidence for pooling and the influence of AL in aversive control was obtained by Wertheim (1965). He trained rats on a two-component multiple free operant (Sidman, 1966) avoidance schedule and varied the response-shock interval in one of the 5-min. components. Response rate in the variable component was a function of the shock density in that component, and the response rate change in the constant component was both smaller in size and opposite in sign from that of the variable component. This contrast effect is easily interpretable in terms of AL theory, assuming that response rate in a component is determined by its aversiveness. When shock density was raised in one component, the apparent aversiveness of the other component would be lessened because the indifference point, or AL, would be lowered.

A contrast experiment performed by Brethower and Reynolds (1962) can be interpreted similarly. These investigators had pigeons key pecking on a VI 3-min. food-reinforced schedule and alternated 3 min. of green light with 3 min. of red light on the key. When continuous punishment was introduced in the red component, response rate decreased in it, and increased in the green component as a function of shock intensity. This contrast effect was again obtained when extinction was programmed during the red component. Terrace (1968) was also able to produce enhanced key-pecking in one component of a multiple schedule by introducing punishment in the other.

A study by Schuster and Rachlin (1968) will be reviewed because it shows the influence of AL on choice behavior, and raises some interesting questions about a response theory of reinforcement. Pigeons were given a choice between response-dependent and response-independent shock by means of a concurrent schedule. Both food reward and 5-min. terminal links were programmed on two independent VI 2-min. schedules on two keys concurrently. Responding during the terminal link associated with one key was punished on a continuous reinforcement schedule, and noncontingent shocks of varying frequency were delivered during the final link associated with the other key. A VI 1-min. food schedule was operative during the terminal link only for the key associated with the link in effect. Both keys were white in the initial link; in the punishment link the operative key was red, and in the noncontingent link the operative key was orange. Pigeons continue to peck both keys during the initial link even though they may prefer the terminal link obtained on one key to that programmed on the other, because responding on both keys maximizes frequency of reward. The proportion of pecking on the two keys in the initial link, reflecting the subjects' preferences, varied with relative shock density in the terminal links, irrespective of the shock's correlation with responding. The relative aversiveness of the two links can easily be related to the pooled effect of the shocks within each link; AL, since it is a weighted average of the shocks over time, would be lowest in the terminal link with the highest shock density. It was also found that response rate was much more suppressed in the punishment link than in the noncontingent shock link. Since proportion of responding in the initial link was related to relative shock density and not relative response rate, stimulus theories of reinforcement are supported against Premack's (1965) response-rate hypothesis. According to Premack's theory, a response preceding a response of lower probability (the pecking on the key in the initial link that was followed by the low-frequency responding in the punishment link) should decrease more than a response preceding a higher probability response (that of responding in the noncontingent shock link). Since the topographies of the responses in the initial and terminal link were identical, this finding may constitute a disconfirmation of a small extension of Premack's hypothesis. Moreover, it may be supposed that this extension need not be made to apply Premack's hypothesis to these data; instead, the unconditioned response (UR) to shock can be designated as the reinforcing event. In the latter case, the correct prediction is made. The question then becomes, which response do we choose? Premack's theory apparently does not supply the answer, at least in its present form. When the shock density is taken to be the important variable in a stimulus theory of reinforcement this problem does not arise.

Quality of the Aversive Stimulus

If only the affectivity of reinforcers, as defined by their difference from the organism's AL, is important in determining their effectiveness, similar results should be obtainable in various aversive control paradigms using qualitatively different aversive events. More specifically, if two qualitatively different aversive stimuli are equated in aversiveness using a procedure similar to that of Campbell (1968), AL theory predicts that these events should affect behavior similarly in any conditioning paradigm. There appears to be little data that bears directly on this prediction, but there is some indirect evidence.

Riccio and Thach (1966) failed to produce a conditioned emotional response (CER) in rats using 1 min. of rotation as the aversive stimulus. The CER technique involves the presentation of an aversive unconditioned stimulus (US) independently of the subject's behavior. If the US is contingent upon another stimulus, this stimulus, the conditioned stimulus (CS), comes to suppress appetitive behavior and facilitate free operant avoidance. The same rotation was later found to be an effective punisher in the same subjects—that is, the rotation did reduce responding when it was response contingent. Assuming rotation to be mildly aversive, these findings agree with those of Annau and Kamin (1961) who showed that low shock intensities are effective in punishment but not conditioned suppression.

Bevan and Turner (1965) attempted to demonstrate a contrast effect with qualitatively different reinforcers in college students to provide evidence for the thesis that only the affectivity of reinforcers determines their effectiveness. Each subject was given a vigilance task that involved pressing a button on occasions when a regularly recurring tone was absent. There were five between-subjects reinforcement conditions: (*a*) nonreinforcement, (*b*) punishment with mild shock for errors, (*c*) reward of a penny for each correct detection, (*d*) punishment in the first half of the session and reward in the second half, and (*e*) reward in the first half and punishment in the second half. It was predicted that performance would be best in the second half of the session for Groups *d* and *e* because the reinforcers used then would be far from the subject's AL on the affective dimension. There was no difference found in number of errors between *b* and *c* or between *d* and *e*. The prediction from AL theory was not verified; the nonreinforced group performed the poorest and the shifted groups made the fewest errors—both before and after the shift. The absence of contrast and the difference between the shifted and nonshifted reinforcement groups before the shift may be explained by the fact that subjects were told what was going to happen in the study before it began.

A replication of the above experiment with "right" and "wrong" as the reinforcers (Bevan & Turner, 1966), and without subjects being informed about the reinforcement contingencies before the study began, supported their contention that instructions caused the lack of contrast. The results of the second experiment were much the same as the first except that the shifted groups' preshift performance was identical to that of the nonshifted reinforcement groups. A large contrast effect was thus demonstrated with qualitatively different reinforcers.

The relative affectivity of qualitatively different aversive events is not the only variable of importance, however. When the unconditioned response (UR) exerts control over the learned behavior, qualitatively different USs which are equated for aversiveness may differ in reinforcing effectiveness, and AL theory will be correspondingly less useful. An important exception to the thesis that only the affective value of a reinforcer is important in punishment, comes from an experiment on rats by Bolles and Seelbach (1964). Employing a punishment and yoked control group, they found that a large increase in noise intensity as punishment would effectively suppress window investigating, but not rearing or grooming, and concluded that the response which the reinforcer unconditionally elicits is crucial. Miller and his colleagues have emphasized the response-eliciting properties of shock in runway situations. Fowler and Miller (1963) have shown with rats that running speed can be increased or decreased depending upon whether shock is delivered to the front or hind paws at the goal. It is important to note that this does not appear to be the case with the CER. LoLordo (1967) observed that a CS produced free operant avoidance facilitation after being paired with a US that elicited suppression. A more striking demonstration of the independence of the CR and UR in CER conditioning has been provided by Baenninger (1967). Using mouse-killing rats, Baenninger found that a CS which preceded shock would suppress mouse killing even though the unconditioned effect of the shock was aggression.

Introduction of Aversive Stimulation

Suppression of Base-Line Responding

One of the major difficulties encountered in the study of aversive behavior is the maintenance of a stable base-line response rate after shock has been introduced. In conditioned suppression studies, variable base-line response rate often makes it difficult to assess the amount of CS-elicited suppression. A more serious problem, however, is that with either a sudden increase in the intensity of shock, or the initial introduction of high shock intensities, animals simply stop responding forever (e.g., Azrin & Holz, 1966).

If punishment (there seems to be no CER studies of this problem) is initially introduced at low intensities, and then gradually increased, subjects do not suppress completely, and will tolerate very high shock intensities, as has been shown for pigeons (Azrin & Holz, 1966; Azrin, Holz & Hake, 1963). In an unpublished study of fixed-ratio punishment of licking a sucrose solution, the present author has found it easy to get hungry rats to tolerate high frequencies of relatively intense shocks by the method of gradually increasing shock intensity over days, and progressively decreasing the ratio of licks per shock. The author has observed a rat administer himself 43 shocks of .8 ma intensity and .5-sec. duration in a 20-min. session on a fixed ratio 32 punishment of licking schedule. Generally, two or three .6 ma shocks given as punishment for licking are more than sufficient to suppress responding for the remainder of the session in rats that have not experienced shock before.

The application of AL theory to these data is straightforward. Assuming that the effectiveness of a reinforcer is determined by its relation to a weighted average of the reinforcements preceding it, the efficacy of gradually increasing the shock intensity and consequently changing the AL in avoiding complete suppression is readily understood. The organism eventually keeps responding in the face of intense punishments because they are, in fact, not perceived as intense by him, due to his reinforcement history.

Sequence of Habituating Stimuli

It was noted several times before in this review that the effects of intense reinforcers can be attenuated if the organism is introduced to the reinforcer in gradual increments. An experiment by Davis and Wagner (1969) illustrated this principle for the startle response, and used some interesting control procedures. In their first experiment three groups of rats, matched for magnitude of startle, were either given 400 50-msec. tones of 120 decibels (db), the same number of tones increasing in 5 db increments to 120 db at the end of the session, or no tone presentations. The number of startle responses to the final 120-db block of testing tones was found to be the same for the two groups that received habituation tone presentations but greater in the nonhabituation group. In Davis and Wagner's second experiment, their rats received one of four habituation treatments: (*a*) 750 120-db tones, (*b*) 750 tones increasing to 118 db in 2.5 db increments, (*c*) 750 100-db tones, and (*d*) 750 tones of the same intensities as those of the gradually increasing group but presented in random order. The gradual group did not increase their frequency of startle responses, despite the increasing loudness of the tones and in contrast to the gradually increasing group of Experiment 1. We would expect from AL theory that the discrepancy is due to the difference in size of the increments. The constant 120-db group, of course, showed adaptation throughout, as did the constant 100 db and random group up until testing. The gradual group gave much fewer startle responses in the last block of trials than the constant 120-db group, which in turn made fewer startles than either the constant 100 db or random groups. It is clear that the difference between AL and the test stimuli would be greatest for the random and constant 100-db group, explaining their high frequency of startle responses.

Recovery and Some Related Phenomena

At moderate shock intensities, but not at high intensities, response rate is initially slowed by punishment, but gradually increases to, and may surpass, its previous level as punishment continues (Azrin & Holz, 1966). A similar phenomenon is often observed in the recovery of base-line responding after introduction of a bar-in CER procedure[3] (Annau & Kamin, 1961). Recovery of CS-elicited suppression has also been observed in a CER experiment at low shock intensities (Annau & Kamin, 1961). The most striking adaptation effect yet reported in the CER literature (Graeber, 1968) factorially manipulated air-puff intensity (three levels) and number of CS air-puff pairings (4, 8, 12, 18, and 24) in a grill-box design. Subjects were tested in a runway situation where the CS appeared at the goal. Suppression of running speed did not vary with US intensity, but decreased with number of pairings. Adaptation to aversive stimuli produces a decrease in responding under other conditions, for example, in the within-session decrement of response rate commonly observed in free operant avoidance paradigms (Sidman, 1966). This decrement is sometimes confined to the initial session, and may reflect the same adaptation process as a decline in responding that often occurs across sessions. Adaptation effects with aversive stimuli are not confined to animal research; Lazarus and Opton (1966) have described the large adaptation of autonomic measures to repeated films of an anxiety provoking nature—for example, of surgery.

Since each reinforcement pulls AL toward itself, recovery of appetitive responding at low and moderate shock intensities is predicted by AL theory. The failure of response-rate recovery at extremely high intensities can be accounted for by the tendency of AL to lag, especially with extreme stimuli, because it is a log mean. The AL theory can also account for the transient increase in responding when punishment is discontinued (Azrin & Holz, 1966) because AL is lower after shock, and positive reinforcers, therefore, will appear more attractive than before punishment was introduced. An analogous phenomenon may be the transient increase in response rate exhibited after suppression to the CS that is sometimes reported in bar-in CER studies (Estes & Skinner, 1941; Ferster & Skinner, 1957).

The Effects of Preshock

In order to make predictions about the effects of shock, both its aversive and cue properties must be considered. It is possible for shock to increase responding if food is made contingent on its presentation, or if it is a discriminative stimulus for the presence of reinforcement (Azrin & Holz, 1966; Murray & Nevin, 1967). The reverse can also occur—that is, shock can predict further aversive stimulation and be more effective than it would ordinarily be, particularly at high intensities. According to AL theory, preshock should make subsequent shocks less effective when the aversiveness of shock is not enhanced by conditioning mechanisms because preshock lowers the subject's AL, rendering further shocks less subjectively intense.

The typical paradigm in the preshock literature is to expose subjects to shocks of various intensities and then to test them on a conditioning task using shock as a reinforcer. All possible results have been obtained and much of the confusion is the result of investigators failing to appreciate the cue properties that shock can acquire, like any other stimulus. Convincing support for this proposition can be found in the studies by Anderson, Cole, and McVaugh (1968). In one of their experiments, they demonstrated that continuous preshock (which, of course, could not function as a predictor of future shock) did not retard running to a punished goal as much as either massed or spaced preshocks. The spaced preshocks were 24 hr. apart, and did not

[3] Bar-in CER procedures are those in which the CS-US presentations occur while the subject is engaged in the behavior to be affected by the CS (the base-line response); bar-out or grill-box procedures are those in which conditioning occurs when the subject has no access to the response manipulandum.

interfere with the instrumental response as much as the massed kind (intershock interval of approximately 3 min.) presumably because an event 24 hr. before another is a much poorer cue for the latter event than if it is 3 min. before. The total amount of shock time was equated for these three groups. More interesting in terms of the purpose of this paper was the comparison between the continuous preshock group and a control which received no preshock. As AL theory requires, the continuous preshock subjects ran faster to the punished goal than the controls, indicating an adaptation effect.

Another preshock experiment relevant to AL theory was conducted by Holmes and Brookshire (1968). They employed eight groups of rats which differed in their treatment in the first 30 days of running a straight alley to food reward. Group GI (gradual inside) received punishment at the goal box that gradually increased in intensity over days to .35 ma; Group FI (fixed inside) was given .35 ma shock at the goal. Two further groups, Groups GO (gradual outside) and FO (fixed outside), were given treatments identical to those of GI and FI in a very different situation outside the runway after the daily runway session. The treatments of Groups FOGI and FOFI are clear from their designation. Group HO (high outside) received 2 ma shock, and Group C was given no shock. Starting on Day 31 all subjects were punished with .35 ma shocks at the goal box. Running speed did not differentiate the groups so mean percentage of approach responses in each group was used as the dependent measure. In the first 31 days, only Groups FI and FOFI showed a reduced percentage of approaches indicating that the GI condition did not disrupt approach behavior and that there was no generalization from the outside shock conditions to the alley. The group performances fell into two clusters after Day 30, differences within a cluster not being significant. The cluster with the high percentage of approach responses was comprised of Groups GI, FOGI, and GO. In the low-response cluster, Group C was the most suppressed but the difference between this group and the others only approached significance.

According to the theory, the groups receiving fixed intensity punishment were the only suppressed groups in the first 30 days because their AL had not been pulled down by shock when punishment started and the shock was, therefore, of great apparent intensity: The same explanation applies to Group C after Day 30. AL changed gradually with increasing shock intensity for the gradual subjects, and the effects of punishment were thereby attenuated for them. From AL theory we would expect Group HO to be less affected by shock than Groups C, FI, and FIFO as it in fact was. It is not clear, however, why it was found to be reliably below Groups GI, GO, and FOGI since AL theory predicts the reverse.

We turn now to a consideration of preshock experiments that were explicitly conceived to test predictions from AL theory. Bevan and Adamson (1960), in an effort to show that performance is a function of apparent intensity, had three groups of subjects judge the intensity of 30 shocks of either 1.3 ma, 2.3 ma, or 3.3 ma before learning a bolthead maze problem in which a 2.3 ma shock was given for each incorrect choice. Acquisition varied with perceived intensity such that subjects with the same intense apparent US (those that judged the 1.3 ma shock) made the fewest errors, and subjects judging the 3.3 ma shock made the most.

Another experiment, similar in principle, was run with rats in a straight alley by Black, Adamson, and Bevan (1961). In a shuttle-box escape task given before the runway tests, shock intensity was varied over three levels, .3, .45, and .5 ma, between subjects. The dependent measure was time to escape a .45 ma alley shock; alley speed was inversely related to preshock intensity. A nonshuttle control ran a little slower than the .3 ma subjects. This rat study replicates the bolthead maze experiment, but AL theory does not predict the performance of the nonshuttle control group.

According to AL theory, preshock should not only attenuate the effect of further aversive stimuli, it should also enhance the effects of reward. MacDougall and Bevan (1968) had rats self-stimulating through electrodes in the median forebrain bundle. On alternate days, subjects were given foot shock before beginning to self-stimulate. Bar-press rate was enhanced on preshock days as predicted by the theory. This phenomenon is formally similar to the contrast effect observed by Terrace (1968) and Brethower and Reynolds (1962) discussed earlier in this review. From AL theory we would further expect that stimuli which are ordinarily neutral ought to acquire positively reinforcing properties when AL is pulled down by negative reinforcement. As mentioned, the findings of Crandall et al. (1964) provide strong evidence for this proposition. An animal experiment (Rescorla, 1969) which is similar to the usual preshock paradigm, documents the generality of this important effect, although it was not designed to test AL theory. Rescorla taught dogs to press two panels on a free operant avoidance schedule. Subsequently each animal received classical grill-box trace conditioning in which CS_1 was followed by a shock 50% of the time and by CS_2 the remainder. Later, subjects were given the opportunity to press both panels on the avoidance schedule again, but now CS_2 was contingent on responding to one panel, whereas another tone was presented for each press of the other panel. It was found that dogs, in general, preferred responding to the panel associated with CS_2. Since there was no preference for either of these tones prior to classical conditioning, it appears as though CS_2 had acquired secondary reinforcing power via contrast with shock. One intriguing aspect of these results is the fact that CS_2 appeared positive several days after the Pavlovian conditioning.

It should be noted that in yet other preshock paradigms, conditioning principles or emotional processes of a different sort than those yet considered appear more important than adaptation phenomena. Among these are the free operant avoidance decrements found by Maier, Seligman, and Solomon (1969) in dogs exposed to preshock; adaptation effects were ruled out in this experiment because the same shocks did not produce the decrement if they were escapable. The absence of adaptation in this instance may be due to a ceiling effect as well as the tendency for AL, a log mean, to lag since very high shock levels were used. Clear evidence of adaptation would be expected if shocks of lesser intensity were used in the avoidance phase, ceteris paribus. Similarly the persistence to continuous punishment obtained after rats received punishment on a partial schedule in a runway situation (Banks, 1966a, 1966b) does not appear to be handled by AL theory because subjects that received shock outside of the runway were not more persistent. Another important nonperceptual variable is the amount of fear present when avoidance conditioning occurs. If intense shock is given immediately before conditioning, speed of learning increases with the amount of fear produced by the shocks. Thus in an avoidance task, using ledge-climbing as the criterion response, Baum (1969) found that a no preshock group made the most errors and an intermittent shock group the least errors while a continuous preshock group fell in between. It is concluded, therefore, that in some preshock experiments adaptation effects contribute only a small portion of the variance, while in others, data are obtained in accord with the theory. A mathematical application of AL theory will be required to determine its role in this area.

Base-Line Reinforcement in Conditioned Suppression

It has often been noted (e.g., Kamin, 1965) that the conditioned-suppression situation essentially represents a conflict between appetitive motivation (determined by some combination of the incentive for the base-line response and the subject's state of hunger) and conditioned fear. The fear is conditioned to the CS and often also to apparatus cues. Because of the antagonistic nature of appetitive motivation and fear, some discussion of the base-line reinforcer from a perceptual framework is relevant to the purpose of this paper.

Ayres and Quinsey (1969) manipulated sucrose concentration (8 and 32%) in a between-subjects design, and found that it did not affect CS-elicited suppression of licking in rats. In a subsequent experiment, 8 and 32% sucrose were alternated within-subjects over days, and a very small but reliable incentive effect was demonstrated on CS-elicited suppression. An AL interpretation is clearly suggested by these data. In the between-subjects experiment, all subjects' ALs would be pulled toward the reinforcement level they were receiving, and the effectiveness of each reinforcer would be lessened. When sucrose concentration was alternated, however, each subject's AL would lie at an intermediate level, between the ALs of the 8 and 32% groups of the first experiment, and, therefore, the discrepancy between the alternated subjects' AL and the 32% solution would be greater than the discrepancy between it and the 8% solution.

Conclusions

Although many of the AL interpretations offered in this paper for various experimental results are post hoc, enough data have been presented to indicate that AL theory is useful in understanding aversive behavior. One of the difficulties in applying the theory is the complexity of the data; it is obvious that principles other than those traditionally part of AL theory are involved. Depending on experimental parameters, results contrary to, or in support of, AL theory can be obtained; the most striking example of this kind of a parameter is the intershock interval employed in preshock studies. In order for AL theory to make genuine predictions in this area, as opposed to being used in "case-fitting," parametric investigations of preshock intensity, time between preshock and testing, and intershock interval are imperative.

In other areas of aversive behavior the applications of AL are often more direct. No further experiments appear necessary to document the existence of contrast effects, adaptation phenomena, the value of slowly increasing reinforcer intensity in attenuating the reinforcer's effectiveness, or the fact that the average reinforcer intensity is the important parameter when the intensity of the aversive stimulus is variable.

The question then arises: What kind of research would yield useful information for further extensions of AL theory to aversive behavior? As mentioned above, study of the effects of qualitatively different aversive stimuli and parametric investigations are needed as well as quantitative applications of the theory. Once parametric data are available it should be possible to obtain numerical values for AL in different situations, and to be able to predict the magnitude of various perceptual phenomena as has been accomplished in the areas of psychophysics and visual perception (see Helson, 1964 for a review and for methods of obtaining AL). The response-eliciting aspects of different aversive stimuli in conditioning are also not well understood, and constitute an important restriction on AL theory. The concurrent VI method of measuring choice behavior (Schuster & Rachlin, 1968) appears to be a particularly informative method for use in future investigations of AL theory in this area because the relative aversiveness of various reinforcers and schedules of presentation can be studied relatively independently of the unconditioned effects of the aversive stimuli, and because within-subject, steady state designs can be used.

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