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SOME IMPLICATIONS OF A RELATIONAL PRINCIPLE OF REINFORCEMENT[1]

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A formal statement of a relational principle of reinforcement is developed that makes contact with analyses of choice, interresponse-time distributions, and stimulus control. Some implications for current theoretical and empirical work in the various areas are examined.

Key words: reinforcement, relational principle, analysis of choice, interresponse-time distribution, stimulus control

In this paper, the relational principle of reinforcement proposed by Premack (1959, 1965) is given a somewhat more formal statement that more explicitly acknowledges the role of the stimulus. This formalization of the reinforcement principle is shown to be consistent with the theoretical analysis of a number of diverse phenomena—including choice behavior, interresponse-time distributions, and the blocking of stimulus control.

Relational Principle of Reinforcement

Consider the following specific illustration of operant conditioning as a means of introducing the necessary terminology: a pigeon is deprived of food and is placed in an experimental chamber containing a response key and a food hopper, from which mixed grain may be made available. In the presence of the stimulus of the key, the key-pecking response may freely occur in the absence of any contingency imposed by the experimenter. The stimulus of the key is referred to as the *noncontingent stimulus* (S_N) and the response of key pecking as the *noncontingent response* (R_N). Conditioning is instituted when the stimulus of the grain, which stimulus controls pecking, is made contingent on a key-pecking response. The stimulus of the grain is termed the *contingent stimulus* (S_C) and pecking the grain is termed the *contingent response* (R_C). When the contingency between key pecking and the stimuli controlling eating is instituted, the frequency of key pecking is observed to increase and the key-pecking response may be said to have been reinforced.

According to Premack, a general statement of the events critical to the occurrence of reinforcement is as follows: in the presence of noncontingent stimuli (S_N), a noncontingent response (R_N) increases in probability if R_N is followed by more preferred contingent stimuli (S_C) which control a second response (R_C) and if the organism has been deprived of the contingent response (Premack, 1965). Note that within the context of Premack's formulation, reinforcement is not a property of either a stimulus or a response but of a relationship between two successive elicitation processes, *i.e.*, S_N-R_N and S_C-R_C (*cf.* Catania, 1971; Morse and Kelleher, *in press*). The preference for an elicitation process is defined as the proportion of time that an organism exposes itself to the stimuli that control the response when given free access to the controlling stimuli *under baseline conditions which are otherwise identical to the conditions prevailing when the contingency is present.* The preference for an elicitation process is most conveniently measured by the probability (p_i) of the response controlled by the eliciting stimulus, and may be defined as

$$p_i = \frac{m(t_i)}{\sum_{i=1}^{n} m(t_i)}, \qquad (1)$$

where m is an appropriate measure of the time, (t_i) spent engaging in R_i when there are

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n alternative responses available. While time has typically been measured as a linear function of clock time in experiments designed to evaluate the relational principle of reinforcement (*e.g.,* Premack, 1965; Terhune and Premack, 1974), other transformations are possible and may ultimately be found to be necessary (*cf.* Killeen, 1972).

An equation for the asymptotic probability of the noncontingent response, p'_N, after the contingency is instituted, that is consistent with the foregoing verbal statement of the Premack principle is

$$p'_N = p_N + k(p_C - p_N), \tag{2}$$

where p_N is the probability of the noncontingent response before institution of the contingency (*i.e.,* the "operant level" of the noncontingent response), p_C is the probability of the contingent response before institution of the contingency, and k is an empirical constant that is a measure of the sensitivity of the organism to the difference between p_C and p_N.

Figure 1, in which p'_N is plotted as a function of the difference between the baseline probabilities of the contingent and noncontingent responses, describes a relationship consistent with Equation 2. If $p_C = p_N$, then $p'_N = p_N$ and conditioning fails to ocur (*i.e.,* the noncontingent response remains at its operant level). If $p_C > p_N$, then reinforcement occurs and p'_N increases as a linear function of $(p_C - p_N)$. If $p_C < p_N$, then punishment occurs and p'_N decreases as a linear function of $(p_C - p_N)$. Equation 2 is consistent both with verbal statements of the relational principle of reinforcement (Premack, 1965, 1971) and with recent empirical work. Specifically, asymptotic probability of the noncontingent response has been shown to vary linearly with the operant level of the noncontingent response (Bauermeister, 1975; Schaeffer, 1965) and with the probability of the contingent response (Langford, Benson, and Weissman, 1969; Premack, 1963; Terhune and Premack, 1970). That reinforcement and punishment may be subsumed under the same law is in accord with other recent observations (Premack, 1971; Rachlin and Herrnstein, 1969; Terhune and Premack, 1970, 1974).

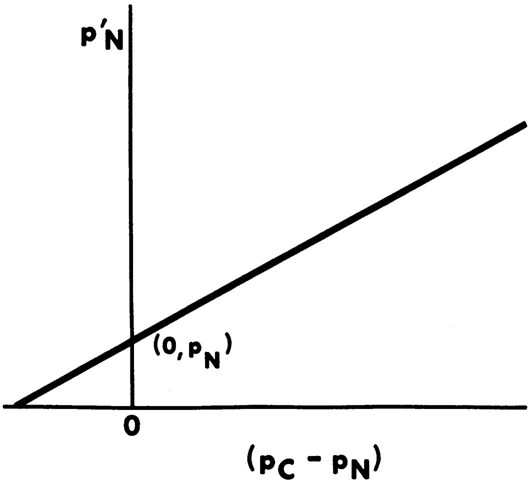

Fig. 1. The asymptotic probability of the noncontingent response (p'_N) following conditioning as a function of the difference between the baseline probabilities of the contingent (p_C) and noncontingent (p_N) responses. The function is that described by Equation 2.

Application to Choice Behavior

Given the statement of the reinforcement principle contained in Equation 2, relationships to the analysis of choice behavior are now explored. In the simplest case, assume that there are two noncontingent responses, R_{N1} and R_{N2}, and that associated with each is a corresponding contingent response, R_{C1} and R_{C2} respectively. (The numerical subscripts denote different responses. Although for ease of communication stimuli are not further mentioned in this section, each response is assumed to have a corresponding controlling stimulus.) The relative asymptotic probability of a noncontingent response after the appropriate contingencies are instituted in the two-choice situation is

$$\frac{p'_{N1}}{p'_{N1} + p'_{N2}} = \frac{p_{N1} + k(p_{C1} - p_{N1})}{[p_{N1} + k(p_{C1} - p_{N1})] + [p_{N2} + k(p_{C2} - p_{N2})]}. \tag{3}$$

Equation 3 may be simplified under conditions that obtain in the most commonly employed, two-choice situation—two key, concurrent variable-interval (VI) schedules with pigeons (Herrnstein, 1970). If the operant levels for the two noncontingent responses are equal and approximately zero, then $P_{N1} = P_{N2} \simeq 0$ and Equation 3 reduces to

$$\frac{p'_{N1}}{p'_{N1} + p'_{N2}} \simeq \frac{p_{C1}}{p_{C1} + p_{C2}}. \tag{4}$$

Equation 4 states that the relative asymptotic probability of a noncontingent response following conditioning is approximately equal to the relative probability of the corresponding contingent response.

Figure 2 illustrates the relationship described in Equation 3 when the operant levels are equal ($p_{N1} = p_{N2} = p_N$) and with p_N and k as parameters. When $p_N = 0$ or when $k = 1$, a straight line with a slope of 45° is obtained. When $p_N > 0$ and when $k < 1$, a family of functions is generated whose slopes decrease as p_N increases or as k decreases. Thus, nonzero operant levels of the noncontingent responses, or a lack of sensitivity to the difference in preferences between the contingent and noncontingent responses, act to reduce the slope. When the noncontingent responses have unequal operant levels, *i.e.*, $p_{N1} \neq p_{N2}$, the resulting functions cross the 45° line at a point that increasingly departs from the point (0.5, 0.5) as the difference between p_{N1} and p_{N2} increases. In the terminology associated with discussions of the matching law, *undermatching* is produced when $p_N > 0$ and *bias* is produced when $p_{N1} \neq p_{N2}$ (*cf.* Baum, 1974*b*). Procedures that produce undermatching would include those in which: (a) the noncontingent response occurs at an appreciable level in the absence of contingencies

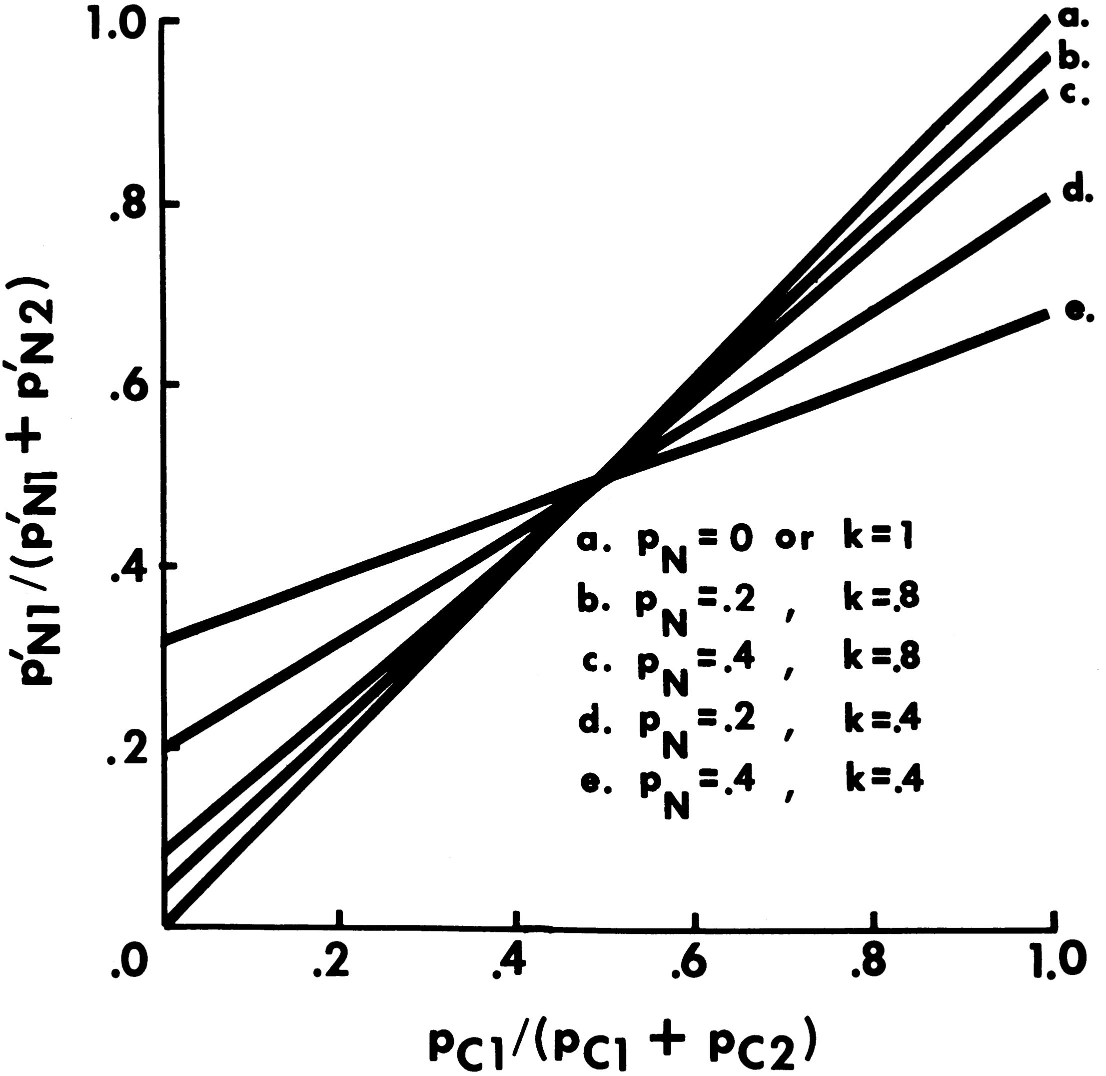

Fig. 2. The relative asymptotic probability of the noncontingent response as a function of the relative baseline probability of the contingent response. The functions are those described by Equation 3 when the baseline probabilities of the noncontingent responses (p_N) are equal and with the p_N and k as parameters. See the text for a more complete discussion.

imposed by the experimenter (*e.g.*, running in an activity wheel), (b) the elicitation process increases the probability of the noncontingent response independent of any experimenter-defined contingency (*e.g.*, R_N is elicited by S_C), and (c) the elicitation process that is contingent on one noncontingent response increases the probability of the other noncontingent response (*e.g.*, induction resulting from such conditions as high deprivation or poor discrimination). Procedures that produce bias would include a host of factors that might differentially affect the baseline levels of the noncontingent responses (*e.g.*, size, location, or force required on the manipulandum).

Equation 4 may be transformed into the usual statement of the matching law (Herrnstein, 1970) by substituting, in accordance with Equation 1, the temporal equivalents of each of the terms in Equation 4 and multiplying both sides of the resulting equation by $\Sigma t / \Sigma t$. (To simplify the notation, clock time, t, rather than a measure of clock time, m(t), will be used in the subsequent developments.) These operations yield

$$\frac{t'_{N1}}{t'_{N1} + t'_{N2}} = \frac{t_{C1}}{t_{C1} + t_{C2}}, \qquad (5)$$

where the subscripts are as defined in Equation 3. If, further, the duration (d) of each reinforcement is constant, as is true in the typical concurrent experiment, then $t_{Ci} = dr_i$, where r_i is the frequency of reinforcement for the *ith* contingent response. When this equivalence is substituted in Equation 5, the relative duration of choice matches the relative frequency of reinforcement for that choice, as shown in Equation 6:

$$\frac{t'_{N1}}{t'_{N1} + t'_{N2}} = \frac{r_1}{r_1 + r_2}. \qquad (6)$$

The matching of relative time allocation to relative reinforcement frequency (Baum and Rachlin, 1969) is equivalent to the matching of relative response frequency if the expected response frequency is linearly related to the duration of choice of an alternative. This condition is met in VI schedules. Thus, under the circumstances described,

$$\frac{R_1}{R_1 + R_2} = \frac{r_1}{r_1 + r_2}, \qquad (7)$$

where R_1 and R_2 are the frequencies of the noncontingent responses. Equation 7 is the standard simplified statement of the matching law. The relational principle of reinforcement, therefore, may generate the matching law under conditions that can reasonably be assumed to hold in the typical study of concurrent VI schedules.

The development of the matching law from a relational principle of reinforcement indicates that the simple matching function is dependent on the particular combinations of parameters derived from a more comprehensive formulation (*cf.* Baum, 1974; Shimp and Hawkes, 1974). As has been suggested by a number of theorists, and as is consistent with the present formulation, the more comprehensive analysis may well be based on the distribution of response *times* and, only fortuitously, on the distribution of response *frequencies* (*cf.* Baum, 1976; Premack, 1965). When the duration of single responses is constant across manipulanda and is small relative to the duration of the experimental session, then response frequency is highly correlated with response time, but not necessarily otherwise.

The interdependence of the relational principle of reinforcement and the matching law is further emphasized when one considers the determination of appropriate baseline conditions for the assessment of times upon which to base estimates of the probabilities of the contingent responses. For a choice situation, baseline conditions that are otherwise identical to those prevailing when the contingency is present must involve the simultaneous availability of those environments that are to follow the noncontingent responses in subsequent contingency sessions. With intermittent reinforcement, those environments include the re-presentation of S_N as well as the occasional presentation of S_C. Thus, the baseline condition for the determination of the probabilities of the contingent responses in the relational principle of reinforcement is identical to that for the determination of the asymptotic probabilities of the noncontingent responses in the matching law, except for any difference in the topography of the noncontingent responses. A concrete example will prove helpful in illustrating this point: the baseline probabilities of the contingent responses might be estimated by recording the amount of time a pigeon spent in either of two halves of an operant chamber, each half of which contained a magazine from which food was available the same proportion of time as would occur in a later contingency session (*cf.* Baum and Rachlin, 1969). Then, in the contingency session, the time spent pecking either of two keys, each of which produced food the same proportion of the time as the baseline session, would provide estimates of the asymptotic probabilities of the noncontingent responses. When the baseline and contingency phases of the experiment are explicitly described as in the above example, it is clear that the correspondence between baseline and contingency sessions in the choice situation is not a test of the validity with which the matching law may be derived from the relational principle of reinforcement, but of the reliability of one principle as assessed by two different noncontingent responses—locomotor behavior and key pecking. It is in this sense that the relational principle of reinforcement and the matching law are analytic (tautological) statements, a matter that has been ably discussed elsewhere (Killeen, 1972). It is possible, and desirable, to attempt to estimate the baseline probabilities of the contingent responses in circumstances that differ from the choice situation in respects other than the absence of the contingency (*e.g.*, in situations containing only one of the contingent elicitation processes), but these efforts require additional empirical analysis and other assumptions than those involved in the formal derivation of Equation 7 from Equation 2.

The convergence of the relational principle of reinforcement and the matching law in the analysis of choice behavior suggests that these two fruitful areas of research may be interrelated with potential mutual profit. Indeed, such efforts have already begun (Baum, 1973; Mazur, 1975). This is not to say that the relational principle of reinforcement is a sufficient basis for the development of a comprehensive analysis of choice. Other variables not reflected by the reinforcement principle must be integrated into a theory of choice. Examples of such additional variables might include interactions among schedule components and reinforcement for other responses, both of which are identified in applications of the matching law to multiple schedules and to single-response situations (Herrnstein, 1970).

Application to IRT Distributions

Interresponse-time (IRT) distributions represent the frequency of occurrence of various times between successive noncontingent responses as a function of the class interval of the IRT (Anger, 1956). Because an organism is continuously behaving (James, 1890; Schoenfeld and Farmer, 1970), the behavior occurring during any given IRT may be viewed as consisting of a series of one or more unmonitored other responses followed by the monitored noncontingent response. From this perspective, all responding occurs in a concurrent situation, although the experimenter may be monitoring only one noncontingent response (deVilliers, 1974; Herrnstein, 1970; Shimp, 1969). By substituting the temporal equivalents of each probability from Equation 1 into Equation 3 and multiplying both sides by $\Sigma t/\Sigma t$, the following equation results.

$$\frac{t'_{N1}}{t'_{N1}+t'_{N2}} = \frac{[t_{N1}+k(t_{C1}-t_{N1})]}{[t_{N1}+k(t_{C1}-t_{N1})]+[t_{N2}+k(t_{C2}-t_{N2})]}. \tag{8}$$

Equation 8 may be interpreted to read that the relative amount of time spent engaging in a series of responses terminated by a specified noncontingent response is proportional to the net relative reinforcement for that series of responses, since, if Equation 8 is true of any one response, it must also be true of a series of such responses. Thus, the relative amount of time within any class interval (relative dwell time) is a measure of the relative preference for those behaviors. (See Shimp, 1967; Weiss, 1970 for a discussion of dwell-time and relative dwell-time distributions as alternative representations of IRT distributions.) This conceptualization of an IRT is at variance with the commonly employed measure of IRT/opportunity (Anger, 1956), since the validity of that measure as an appropriate index of behavioral processes rests on the assumption that the monitored response may occur at any moment in time. Thus, a failure to respond is a missed "opportunity" to respond. The present notion is most congenial with the view that the duration of an IRT is determined at the beginning of the interval when the response is initiated, and not at the termination of the interval (Shimp, 1969).

If Equation 8 is generalized to *n* responses and each term in brackets on the right is designated as the value of that response, $v(R_i)$ (Baum and Rachlin, 1969), then

$$\frac{t'_{N1}}{\sum_{i=1}^{n} t'_{N1}} = \frac{v(R_i)}{\sum_{i=1}^{n} v(R_i)}. \tag{9}$$

Equation 9 is a particularization of Luce's choice axiom (Luce, 1959) and specifies a ratio scale of preference that is unique except for multiplication by a positive constant. That is, changes in the time spent within any class interval of the dwell-time distribution may be produced only by multiplying the distribution by a constant *as long as the relative values of the responses remain constant.* (The relative values might change because of changes in the schedule of reinforcement, *e.g.*, by a shift from a VI schedule to the differential reinforcement of a specified IRT.) Note: since an IRT distribution may be estimated from its corresponding dwell-time distribution by dividing each class interval of the dwell-time distribution by its respective midpoint, the foregoing applies—with this addition—to the IRT distribution as well.

Possible examples of experimental manipulations that might change the mean response frequency without changing the relative values of the IRTs comprising the underlying IRT distribution might include shifts in the mean interreinforcement interval over a range of VI schedules, behavior during the constant VI component after a shift from *mult* VI-VI to *mult* VI-EXT, brief generalization tests, or the early stages of extinction following VI training. What data are available for IRT distributions obtained under the foregoing conditions are consistent with the expectation of invariant relative IRT distributions (Collins, 1974; Crites, Harris, Rosenquist, and Thomas, 1967; Migler, 1964; Migler and Millenson, 1967; Sewall and Kendall, 1965; Weiss, 1972). More information is clearly needed. It should be noted that the postulated invariance of the shapes of the relative IRT distributions provides a rationale for the use of relative generalization gradients in the comparison of the shapes of gradients that differ in mean rate and are characterized by IRT distributions that differ by a multiplicative constant.

While it must be re-emphasized that more information is required before the contributions of the relational principle of reinforcement to the analysis of IRT distributions may be properly evaluated, the point at this juncture is that such relationships do in fact exist.

Application to Stimulus Control

In the previous section, some implications of the relational principle of reinforcement for the conceptualization of IRT distributions were explored in the context of procedures used in the study of stimulus control—*i.e.*, multiple schedules and stimulus generalization tests. While the analysis of stimulus control may be pursued further (Donahoe and Miller, 1975), to do so here would require a more extensive presentation of theory and data than is appropriate for present purposes. Attention is directed, instead, to the relationship between the Premack principle and those classes of stimulus control procedures used for the study of blocking. In the prototypic blocking design (Kamin, 1969), conditioning occurs in the presence of one stimulus during the first phase of the experiment and, then, is continued during the second phase in the presence of a simultaneous compound whose components consist of the original stimulus and a new stimulus. For example, conditioning might first occur in the presence of a tone and then continue in the simultaneous presence of both the tone and a light. Blocking is said to occur if, when compared to behavior in appropriate control conditions, a final test phase reveals that control of the response by the new stimulus component is absent or attenuated.

The blocking phenomenon may be interpreted from the perspective of a relational principle of reinforcement as follows: during the first phase of the experiment, a noncontingent stimulus (S_{N1}) comes to control the response, R_N, with high probability through the institution of a conditioning procedure. (The numerical subscripts now refer to different stimuli and not responses, since only one noncontingent response is at present under consideration.) At the conclusion of the first phase, the asymptotic probability of R_N is given by Equation 10 as

$$p'_{N1} = p_{N1} + k(p_C - p_{N1}). \tag{10}$$

Thus, at the outset of the second phase, the baseline level of R_N is p'_{N1} and not p_{N1}. The elevated baseline is crucial to the analysis since, according to the relational principle described in Equation 2, conditioning is a function of the *discrepancy* between the probabilities of the entering behavior and the contingent behavior. The mere contiguity of R_N with the elicitation process is not sufficient to produce behavioral change. At the conclusion of the second phase of the experiment, during which a second noncontingent stimulus (S_{N2})

is paired with S_{N1} to form the compound stimulus S_{N12}, the asymptotic probability of R_N is given by Equation 11a as

$$p'_{N12} = p'_{N1} + k(p_C - p'_{N1}); \tag{11a}$$

or

$$\Delta p_{N2} = p'_{N12} - p'_{N1} = k(p_C - p'_{N1}). \tag{11b}$$

In Equation 11b, the maximum change in the control of R_N by S_{N2}, Δp_{N2}, is shown to be severely restricted. At the beginning of the blocking stage, p'_{N1} is already large relative to p_C and, hence, little or no increment in the probability of R_N in the presence of S_{N2} may occur during the blocking stage. Note that if $k = 1$, then $\Delta p_{N2} = 0$. If $k < 1$, then $(p_C - p'_{N1}) > 0$ but $k(p_C - p_N)$ is small, due to the lack of sensitivity of the organism to the difference in probability between the contingent and noncontingent responses. Thus, stimulus control of R_N by S_{N2} is blocked and this blocking is consistent with the present formulation of the Premack principle. Note that if S_{N2} causes reduction in the control of R_N by S_{N1} when the two stimuli are first paired (external inhibition), or if the value of p_C changes from the first to the blocking stage, then less blocking will occur.

The formal similarity of Equation 11b to the fundamental equation of the Wagner-Rescorla model of associative learning (Rescorla and Wagner, 1972) given below is apparent.

$$\Delta V_X = \alpha_X \beta(\lambda - V_{AX}) \tag{12}$$

In their notation, ΔV_X is the change in associative strength to stimulus X (S_{N2} in the present notation), α and β are parameters reflecting characteristics of stimulus X and the reinforcing stimulus respectively, λ is the asymptotic value of associative strength for the given reinforcing stimulus, and V_{AX} is the net value of associative strength between the response and AX compound (A is S_{N1} in the present notation) at the beginning of the blocking stage. Thus, while the Wagner-Rescorla model deals with trial-by-trial changes in associative strengths, and not with steady-state probabilities, and introduces additional parameters reflecting the properties of S_{N2} and S_C, both Equations 11b and 12 imply that the change in performance during S_{N2} is proportional to the difference between asymptotic performance and performance at the outset of the blocking stage. This prediction has been supported with both classical (Kamin, 1969; Rescorla, 1969; Wagner, 1969) and operant (Mackintosh and Honig, 1970; Miles, 1970) procedures. The recent application of the Rescorla-Wagner model to generalization data (Blough, 1975) is consistent with the relationships presented here.

As was true of research related to Herrnstein's matching law, the Wagner-Rescorla model also deals with variables and relationships that are not intrinsic to the statement of a relational principle of reinforcement. For example, the phenomenon of overshadowing, whereby of two stimuli paired with reinforcement from the outset of training only one gains control over a response (Miles, 1969; Miles and Jenkins, 1973), is not implied without additional assumptions regarding the relative "salience" of the stimuli (Rescorla and Wagner, 1972). Once again, the point being made is simply that there are important relationships between the Premack principle of reinforcement and another, seemingly independent, area of inquiry.

CONCLUDING COMMENTS

The present formalization of Premack's relational conception of reinforcement has been shown to be consistent with: (a) Herrnstein's matching law under conditions that obtain in typical empirical investigations of choice, (b) an interpretation of IRT distributions that leads to implications regarding permissible transformations for such distributions and for the comparison of generalization gradients differing in response frequency, and (c) the Wagner-Rescorla analysis of the blocking phenomenon in stimulus control. In addition to providing a framework for the potential integration of the experimental and theoretical analysis of these problem areas, a relational view of reinforcement leads in each instance to new interpretations of existing data and suggestions for further research. Many difficulties remain before a truly quantitative account may be given (*cf.* Navarick and Fantino, 1974, 1975)—*e.g.,* the determination of a suitable metric for clock time—but the fact that a relational principle of reinforcement makes contact with a considerable range of phenomena permits the independent assessment and cross-validation of parameter estimates and scaling assumptions.

Somewhat more broadly, a relational principle of reinforcement facilitates the theoretical development of several aspects of the reinforcement process. First, as has been pointed out previously (Baum, 1973), reinforcement may be most generally interpreted as a response-contingent transition between environments differing in the value of successive elicitation processes. Such an interpretation gives promise by yielding similar functional accounts of both unconditioned and conditioned reinforcement (Baum, 1974*a;* Denny, 1967; Wyckoff, 1959).

Second, the demonstration of an intimate association between a relational principle of reinforcement and the matching law provides some perspective on the issue of the relative utility of molar and molecular accounts of the reinforcements process (*e.g.,* Hale and Shimp, 1975; Herrnstein and Loveland, 1975). In a molar account, the distribution of choice responses is said to reflect an integration over time of the reinforcing events subsequent to the various responses. In a molecular account, choice responses are said to be fundamentally determined by discrete response-reinforcer relationships from which the molar account is derivative under certain conditions. The relational principle of reinforcement, in common with the molar approach, indicates that contiguity of response and reinforcer is not sufficient for conditioning. In common with the molecular approach, however, the relational principle indicates that contiguity is necessary for conditioning. As has been observed elsewhere, "matching [a molar account] and maximizing [a molecular account] may be dual aspects of a single process, which is the process of reinforcement itself" (Herrnstein and Loveland, 1975, p. 113). What is suggested here is that the process described by a relational principle of reinforcement may provide such an integration.

Discussions on the molar-molecular issue have occurred in the past few years among those employing classical conditioning procedures for the study of behavioral change. The issue has been largely resolved (or reformulated) within the context of the Rescorla-Wagner analysis, a theoretical analysis consistent with the relational interpretation of reinforcement proposed by Premack (1965). Although it initially appeared that many phenomena produced by classical conditioning procedures were best described on a molar level (Rescorla, 1967), further inquiry has shown the molar descriptions to be of primarily verbal convenience, and either inconsistent with or not required by a comprehensive molecular account (Rescorla, 1972). A case may be made that recent work involving the manipulation of molecular response-reinforcer events within operant conditioning procedures is moving in a similar direction (*e.g.,* Benedict, 1975; Hale and Shimp, 1975; Hineline, 1970; Shimp, 1966). It should be noted that the problem of the temporal integration of events is not circumvented by a molecular approach: The problem simply appears in an altered form—that of the effects of delay of reinforcement.

Lastly, and most generally, since the relational principle of reinforcement and the Wagner-Rescorla analysis lead to similar interpretations of the conditions necessary for behavioral change (Equations 2 and 12), these formulations encourage the view that the two procedures of operant and classical conditioning involve fundamentally similar processes. To be specific, in both procedures, the environment (S_N), into which the elicitation process (S_C-R_C) is intruded, comes to control that behavior which occurs in the presence of S_N. In the classical procedure, that behavior is R_C to a first approximation. In the operant procedure, that behavior is R_N as well as R_C. The ultimate behavioral outcome of any particular realization of either procedure is the product of the interaction of R_C with other concurrent responses, notably R_N in the operant procedure.

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