Toward empirical behavior laws:

I. Conditioned reinforcement'

Evalyn F. Segal
SAN DIEGO STATE COLLEGE

Abstract

A "totality of reaction" hypothesis, based on Premack's theory of reinforcement, seems to encompass a variety of conditioned reinforcement data.

There are two views current on how to establish conditioned reinforcers. The first emphasizes respondent conditioning, i.e., the pairing of stimuli. This method works well in experiments on conditioned negative reinforcers, where a stimulus that has been paired with onset of electric shock eventually acquires aversive properties of its own (Dinsmoor, 1954). The method sometimes works with conditioned positive reinforcers (Ellison & Konorski, 1964; Kelleher & Gollub, 1962; unpublished data from this laboratory) and sometimes not (Kelleher & Gollub, 1962; Schoenfeld et al, 1950). The second view emphasizes "cue functions" (Wyckoff, 1959) in secondary reinforcement, i.e., establishing the stimulus as an S^D for an operant. It seems to be generally successful in experiments on conditioned positive reinforcers (Kelleher & Gollub, 1962; Zimmerman, 1957, 1959), although not all S^D 's are effective conditioned positive reinforcers (Kelleher & Fry, 1962; Kelleher & Gollub, 1962).

A theory that will encompass the data implicating respondents and those implicating cue functions is not yet available. The present theory is an extension of Premack's (1959), which states that the strength of a reinforcer is a positive function of the rate of responding that occurs in its presence. Although his tests of the theory have focused on stimuli that evoke operant responses, nothing in Premack's formulation dictates such a restriction. Consider, therefore, the following hypothesis: The strength of a reinforcer (conditioned or unconditioned) is a function of the totality of reaction to it, where reaction means operant or respondent or both, and totality means total number, rate, intensity, or magnitude of responses of any kind. As the totality of reaction evoked by a reinforcer increases, the reinforcing effect changes nonmonotonically, becoming, first, increasingly positive, and then decreasingly positive, and then increasingly negative.

Figure 1 is a rough illustration of the idea. Although the form of the illustrated function is assumed to be constant, the specific parameters of the underlying monotonic function relating totality of reaction to stimulus intensity are assumed to differ for different reinforcing stimuli. Thus, totality of reaction to electric

Fig. 1. A hypothetical reinforcing-effect function.

shock would probably increase very rapidly as the intensity of the shock was raised, while totality of reaction to a food reinforcer would probably increase only slowly, as the magnitude of the reinforcement increased, or its quality improved, or the deprivation for food increased. Notice particularly that no distinction is made between operant reactions to discriminative stimuli, and respondent reactions elicited by conditioned stimuli. In short, the hypothesis proposes to encompass respondents and cue functions by ignoring the respondent-operant distinction and concentrating on quantity of reaction.

The hypothesis appears to be consistent with many reinforcement data.

(1) The distinction between the positive reinforcingness of food, or conditioned stimuli paired with food, and the negative reinforcingness of shock, or conditioned stimuli paired with shock, might relate to the differential totality of reaction: low-intensity, discrete, parasympathetic reactions to food, high-intensity, diffuse, sympathetic reactions to shock. The qualitative differences between PNS and SNS arousal may not explain the difference in the sign of the reinforcing effect of food and shock. Gellhorn (1964) points out that the PNS may predominate in moods of depression as well as relaxation, and the SNS in happy as well as tense moods. Location on the totality-of-reaction dimension may better identify the state as positively or negatively reinforcing. Very mild shock may be positively, rather than negatively, reinforcing (Harrington & Linder, 1962). Mild shock must elicit less totality of reaction than strong shock, and so remain on the positive side of the reinforcing-effect function.

(2) Medium concentrations of NaCl are more positively reinforcing than lower or higher concentrations;

very high concentrations may be aversive (Young & Falk, 1956). The data fit the hypothetical function on the assumption of a direct relation between NaCl concentration and totality of reaction. High concentrations of foods such as glucose (Eliot Stellar, personal communication) or sucrose (Marx et al, 1963; Premack & Hillix, 1962; Allan Schrier, personal communication) may be less positively reinforcing than lower concentrations, when given in large or closely-spaced doses, although not when given in small or widely-spaced doses. Large or closely-spaced doses of highly concentrated sugars may evoke a greater totality of reaction, and therefore be located on the decreasing limb of the function. Higher intensities of brain stimulation in some loci may be less reinforcing than lower intensities, when presented on CRF schedules, although the higher intensities are more reinforcing when presented intermittently (Beer et al, 1964; Keeseey, 1964; Valenstein, 1964). If a single stimulus of high intensity evokes an optimal totality of reaction, many, closely-spaced, high-intensity stimuli may evoke too much reaction, driving the function toward the decreasing limb. Experiments where low intensities of light or sound are positively reinforcing, while high intensities are negatively reinforcing, are also consistent with the hypothesis, as is the observation that people will voluntarily seek out experiences that are "thrilling"; people go to horror movies, and ride on roller coasters, situations that surely elicit a considerable amount of SNS activity. Apparently, the safe context limits the amount of SNS arousal, and so keeps the situation on the positively reinforcing side of the reinforcing-effect function (at least for some people).

(3) Some brain stimulation is more effective as a reinforcer on CRF than on intermittent schedules (Valenstein, 1964): If the ICS is presented too intermittently, the conditioned operant extinguishes. Perhaps the ICS evokes only a small totality of reaction, and hence only a weak positive reinforcing effect. Pliskoff & Hawkins (1964) have shown that intermittent ICS reinforcement works very well within a chain. Rats maintained stable bar-pressing rates on widely intermittent schedules to produce a conditioned reinforcer correlated with the opportunity to self-stimulate on a CRF schedule on another lever. It is conceivable that the conditioned reinforcer was more reinforcing than ICS itself, for it may have evoked a greater totality of reaction: shifting to the ICS bar and pressing it, as well as reactions elicited by ICS.

(4) A stimulus may be both positively and negatively reinforcing: S will work to produce it and then to remove it. Some sites of brain stimulation are examples (Valenstein, 1964). In another example (Premack, 1963), rats bar pressed to turn on a running wheel, and while running licked at a drinkometer to stop the wheel. A small amount of forced running seems to be on the positive side of the reinforcing-effect func-

tion, a larger amount on the negative side.

These data, and others to be reviewed elsewhere (Segal, 1965), are consistent with several theories of reinforcement. The present hypothesis is worth considering because it embraces a variety of reinforcement phenomena in a simple framework, it is testable, and it leads to some interesting, contrary-to-common-sense, predictions. For example, one implication of the hypothesis is that, within limits, increasing the reaction to a stimulus in any way whatever, even by pairing it with shock, will increase the positive reinforcingness of the stimulus. This implication was the subject of an experiment reported elsewhere (Segal, 1965).

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Note

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