that sulfhydryl groups should vary during the cell cycle of mammalian cells. Variations in sulfhydryl groups during the cell cycle have already been observed in other organisms (5).

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Reinforcement Reduction: A Method for Training Ratio Behavior

Abstract. *By use of intracranial stimulation as reinforcement, fixed-ratio performance could be established directly from continuous reinforcement by gradual reduction of the train duration of the stimuli contingent on all but the terminal response in the desired ratio. Furthermore, stimuli of subreinforcement strength enhanced ratio performance when introduced after training by the conventional method.*

The usual method of training behavior under fixed- and variable-ratio schedules of reinforcement is to gradually increase the response-to-reinforcement ratio from a CRF (continuous reinforcement) schedule until the rate of response is stable under the desired ratio. When one generalized to extralaboratory situations it has generally been assumed that behavior under intermittent schedules of reinforcement is established and maintained according to this procedure.

An alternative method for the acquisition of ratio behavior is proposed: Instead of one withholding reinforcement completely and gradually increasing the response-to-reinforcement ratio, the desired ratio can be established directly from CRF by gradual reduction of the magnitude of the reinforcements contingent on all but the terminal response in the ratio chain. For instance, to establish a fixed-ratio 50 : 1 contingency from CRF, each 50th response is reinforced at optimal level while the mediating 49 responses are continuously reinforced at progressively decreasing magnitudes until behavior is stable under the ratio.

To test this proposed procedure, electrical intracranial stimulation was used as a reinforcer since it allows precise variation in magnitude of reinforcement along several parameters such as amplitude and pulse-train duration.

Adult male Long-Evans rats were permanently implanted with bipolar electrodes aimed at the anterior lateral hypothalamic area (*1*). The rats were tested for intracranial self-stimulation in a Skinner box, and their behavior was monitored with a cumulative recorder. Intracranial reinforcement consisted of 100-cy/sec a-c sine waves, with pulse-train duration kept constant at 0.5 second; current, adjusted individually for each animal, ranged from 200 to 450 μa.

After practice under CRF, training was begun under fixed-ratio schedules in the manner described above. Current levels were kept constant for all reinforcements, while the duration of the pulse trains was gradually decreased to zero for all but the terminal reinforcement in each ratio chain. Care had to be taken not to strain the schedule by premature reductions in pulse train. Generally, the greater the reduction in duration of the train, the more responses the animals had to be allowed at each level before further reduction was possible. Sometimes speed of response increased as the train durations became shorter. Five animals were trained in this manner: two under fixed ratio 16 : 1 and three under fixed ratio 32 : 1; in each instance the training was completed in less than 3 hours of one session, including the initial practice under CRF. Instead of pulse-train duration, amplitude could have been used to vary the magnitude of reinforcement, but use of amplitude was not attempted. but use of amplitude was not attempted.

Two more rats were trained to fixed ratio 32 : 1 by the traditional method of gradually increasing the size of the ratio; train durations were set at 0.5 second. After training, stimuli of 0.03-second duration were made contingent on all responses in the ratio, in addition to the optimal reinforcements already contingent on each 32nd response; in both instances the rate of response increased as performance became less strained. Furthermore it was possible to increase the ratio directly to fixed ratio 50 : 1 without affecting performance. When the optimal reinforcement was then completely withheld, leaving only the stimuli having 0.03-second train duration, all animals extinguished after a few hundred responses. This finding indicated that intracranial stimuli of subreinforcement magnitude can affect behavior, or function as reinforcers (perhaps conditioned reinforcers) when administered in the context of reinforcing stimuli.

The method of reduction in reinforcement may have practical application for training under intracranial reinforcement, and at least conceptual applications to reinforcement schedules, in and out of the laboratory, using traditional rewards. As a training method it allows direct acquisition under a particular ratio without requiring practice under smaller ratios; this feature could be of advantage in studies in which practice under smaller ratios would contaminate performance or extinction under the desired ratio.

With regard to human behavior, it is conceivable that verbal and other types of social reinforcement can be and are administered in a similar manner to establish and maintain ratio behavior.

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Reference and Notes

1. The stereotaxic coordinates used were reported for the anterior lateral hypothalamus by J. Bogacz, J. St. Laurent, J. Olds, *Electroencephalog. Clin. Neurophysiol.* **19** 75 (1965); the electrode placements were confirmed histologically.
2. I thank A. W. Mills and Benjamin Pressman.

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