second reference solution of the same measured orthophosphate concentration as that of the soil extract, for example, $182 \times 10^{-7} M$, was shaken with the resin between treatments with the soil extract. Points on the same line were obtained. In addition to providing a second comparison, this indicates the absence of other anions in the soil extract in sufficient concentration to upset the orthophosphate equilibrium between resin and solution.

If the reactive forms of phosphate in the reference calcium chloride-orthophosphate solutions and the soil extract had not been identical, then the resin would have behaved differently towards each solution. Consequently, the dissociation of any complex phosphate present in this soil extract had no significant influence on the orthophosphate ion equilibria in the soil system, nor was any existing complex significantly dissociated in the strongly acidic solutions used for subsequent analyses. The only possible exceptions could be polymeric forms derived from orthophosphate ions.

Similar results were obtained for a soil extract prepared by only 10 min. shaking in 0.01 *M* calcium chloride solutions, and for an extract from a purified kaolinite after 12 hr. shaking.

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PSYCHOLOGY

Dissociating Reward from Response in Electrical Self-Stimulation in the Rat

It has been shown that animals with chronically implanted electrodes will repeatedly operate a pedal to stimulate certain areas of their own brains. The responding differs in several ways from that of orthodox conditioning procedures: it is highly resistant to satiation, fatigue and distraction, and it continues unaffected when known physiological needs are fully satiated. If the stimulating current is stopped, extinction follows almost immediately, although 'one-trial' relearning occurs when the current is again applied. To explain these features it has been suggested that the electrical shock to the brain serves merely to 'energize' a compulsive and automatic repetition of the general pattern of activity present before receipt of the shock, and that electrical shock to the brain is not 'rewarding' in the usual sense¹⁻³.

To test this suggestion, 6 rats with hypothalamic electrodes, previously trained on the self-stimulation procedure, were allowed to respond with a 0.5-sec. 50-c/s electrical shock to the brain following each depression of the pedal at a voltage previously established as optimal for each rat (condition A). After 3 min., a metronome-controlled stimulator was switched into the circuit to deliver a 6 min. train of shocks of the same voltage and pulse duration, and given at the animal's mean frequency of responding in the previous 3 min. These shocks were independent of the animal's responses (condition B). Unless the electrical shock to the brain given in this way is

Fig. 1. Cumulative records of pedal presses. Fused downstrokes on each trace mark receipt of metronome-controlled shocks

punishing, a 'compulsion theory' would predict that responding would be maintained under this condition. After a return to condition A for 3 min., a third condition (C) followed, in which the train of the electrical shock to the brain was discontinued if the animal stopped responding for more than 5 sec. The train could be restarted by a single further response. This tested the possibility that forced electrical shock to the brain develops aversive properties. Conditions B and C were each followed by a 2 min. extinction period (D), during which the stimulating current was switched off.

Fig. 1 shows two selected cumulative records. The responding of rat I was unaffected, whereas rat II showed a prompt and lasting extinction when the electrical shock to the brain was dissociated from the operation of the pedal under condition B. Of the remaining four records, one resembled I, one resembled II, and two were intermediate. The maintained responding illustrated under condition C was found in all animals, and indicates that the forced electrical shock to the brain was not punishing.

A number of explanations are possible for the two cases which continued to respond under condition B, but the prompt or gradual onset of extinction in the remaining four animals indicates that not all cases of self-stimulation can be explained as compulsive or automatic reactions.

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