THE ABOLISHMENT OF A DISCRIMINATION

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I.—The following formulation of the process of discrimination has been tested experimentally, as reported elsewhere.[1] Two stimuli, S_1 and S_2, eliciting the same response (R), possess some of their properties in common but differ also in some significant respect. In establishing a discrimination the reflex in response to one of them (S_1) is reinforced, while that in response to the other (S_2) is extinguished. Because of the similarity of the stimuli the two processes cannot go on independently, and their mutual interference constitutes the special problem of discrimination.

The resulting difference in behavior with respect to the two stimuli may be abolished in either of two ways. The reflex $S_1 - R$, hitherto reinforced, may also be extinguished, or the reflex $S_2 - R$, hitherto extinguished, may be reconditioned. The strengths of the two reflexes will then be equal, at some value near zero in the former case or near a maximum in the latter, and the discrimination will have disappeared. The present paper is concerned with the properties of these two kinds of change. One typical case of each sort is described. The conclusions are supported by about fifteen other cases, and no serious exceptions have appeared.

The responses of a white rat in pressing a small lever are recorded automatically[1] in the form shown in the figures, which are number-time graphs for the responses during one hour or more. Such a response may or may not be reinforced by the delivery of a pellet of food, at the will of the experimenter. The stimulation arising from the lever may be modified, for purposes of discrimination, by the addition of light from a small bulb.

Discriminations were established in the manner described elsewhere.[1] On the seventh day the strength of the extinguished members ($S_2 - R$) had reached the low values given by the slopes of the curves in figures 1*A* and 2*A*. The periodic reconditioning of the reinforced members ($S_1 - R$) occurred at the vertical bars above the records. The two cases differ in one respect: with Rat *KI* 46, S_1 consisted of the stimulation from the lever plus the light and S_2 of the stimulation from the lever only; with Rat *KI* 44 this was reversed. A comparison of the two methods is in preparation; the present argument is not affected.

II.—The first case, in which the previously reconditioned member is extinguished, is represented in figure 1. Record *B* was taken on the ex-

perimental day immediately following A, or on the eighth day of the discrimination. For about 45 minutes the usual periodic reconditioning of the response to the lever plus light and the intervening extinction of the response to the lever alone were carried out. After the eighth interval the light was turned on permanently and none of the subsequent responses was reinforced.

In making this change we establish the conditions for the extinction of $S_1 - R$, and we should therefore expect to obtain a curve which is similar to that previously reported for the extinction of a reflex of this sort.[2] The curve in figure 1 has the required properties. The only significant

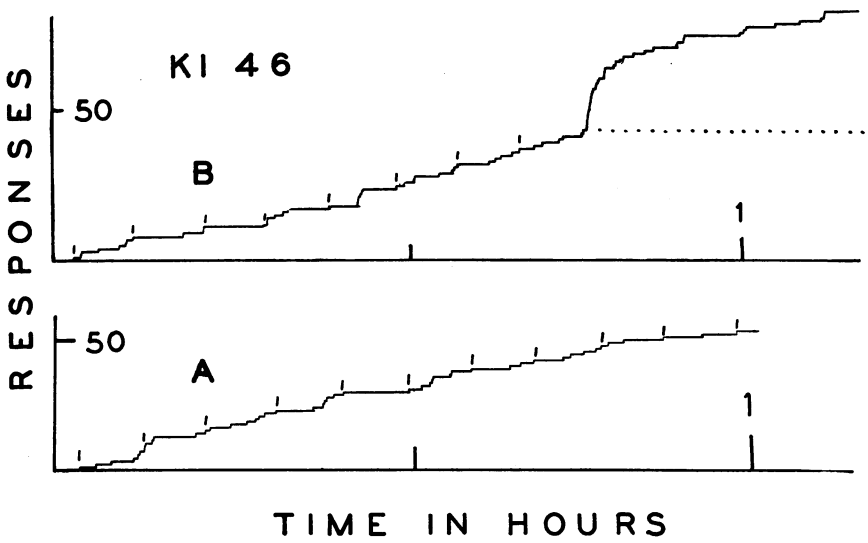

FIGURE 1

difference is the absence in the present case of a cyclic fluctuation. But this is to be predicted from the explanation advanced,[2] since the emotional effect to which the fluctuation is supposed to be due has here had ample opportunity to adapt out.

The area under the curve is somewhat less than that for original extinction and the curves are often smaller than the example here given. Apparently, then, the periodic reconditioning of the reflex $S_1 - R$ has not been wholly effective in maintaining its full strength or at least its full resistance to extinction.[3] It has already been shown that the concurrent reconditioning of $S_1 - R$ prevents the rapid extinction of $S_2 - R$, and we must now recognize a reciprocal effect of the extinction of $S_2 - R$ upon either the strength or the resistance to extinction of $S_1 - R$.

III.—In the second case, in which the previously extinguished member is reconditioned, the reconditioning could be effected very quickly by

successive reinforcements. But changes of this kind are too rapid to permit close analysis,[3] and for this and other reasons it is advisable to restore the extinguished reflex not to a maximal strength but to the intermediate strength observed under the original periodic conditioning prior

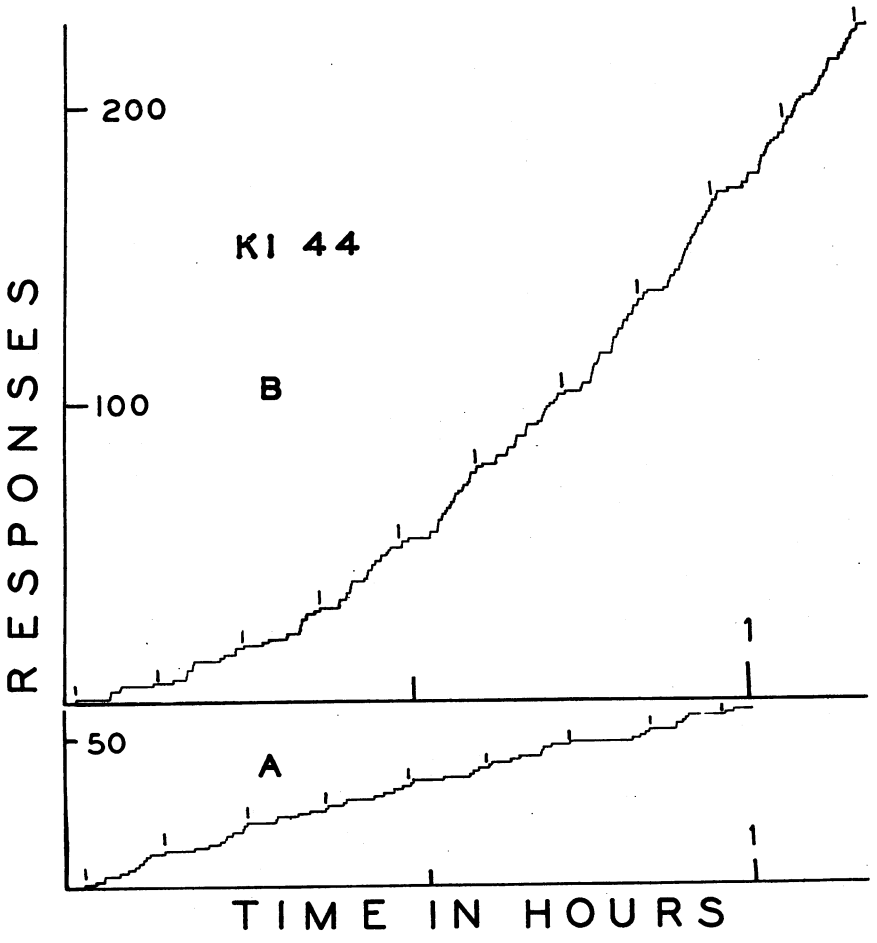

FIGURE 2

to any discrimination.[1] S_1 is therefore omitted altogether, and $S_2 - R$ is periodically reconditioned at the selected interval.

The typical result is shown in figure 2. Record *B* is for the day following record *A*. All responses are to S_2, and since these responses have not been reinforced during the discrimination, the rate begins at the low value given in record *A*. Periodically, however, the response is now reinforced, and the strength of the reflex gradually increases until it strikes a con-

stant value, which for our present degree of approximation is identical with that originally assumed prior to the discrimination. Except for minor local deviations the curve shows a smooth positive acceleration. It should be compared with figure 2 in the first reference,[1] which shows the original development of a constant rate under periodic reconditioning.

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[1] "The Rate of Establishment of a Discrimination," *J. Gen. Psychol.* (in press).

[2] "On the Rate of Extinction of a Conditioned Reflex," *Ibid.*, **8**, 114–129 (1933).

[3] " 'Resistance to Extinction' in the Process of Conditioning," *Ibid.* (in press).

CRYSTALLIZATION OF A COMPOUND OF HEMOGLOBIN AND CARBON DIOXIDE

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The question whether hemoglobin combines with CO_2 has been in dispute since such combination was claimed by Bohr[1] in 1909. Previous to Adair's[2] paper in 1925 there was little agreement concerning either the amount of CO_2 combined by Hb or the nature of the combination. Adair showed that the disagreement concerning the amount was attributable to previous failure to remove completely mineral base from the hemoglobin preparations used: in consequence saturation with CO_2 produced mineral bicarbonate in addition to any CO_2 combination formed with the Hb. Adair found that purified hemoglobin in solutions to which free carbonic acid was added did in fact combine reversibly with the latter, and that the compound in its osmotic behavior resembled a bicarbonate, $HbHCO_3$ or $Hb(HCO_3)_2$, the latter formula apparently representing the maximal amount of CO_2 that could be combined. Adair's experiments were performed with pure HbO_2 and pure CO_2 in water solution, so that the reaction was on the acid side of the isoelectric point of oxyhemoglobin, which is at about pH 6.7. At such acid reactions hemoglobin forms salts with acids in general; its behavior with carbonic acid was therefore what would be expected merely from the acid properties of H_2CO_3. In 1928, however, Henriques[3] reopened the question. He showed that several facts in the behavior of blood could be explained by assuming that hemoglobin, when at physiological pH, and therefore on the alkaline side of the isoelectric point, combines reversibly with CO_2, and by assuming that the "carbhemoglobin" so formed is not of the nature of a bicarbonate salt, but is rather a molecular combination with anhydrous CO_2, more nearly