

2 was arbitrarily set at zero and other scores were plotted in a negative direction below zero. In similar fashion to Hull's treatment of hypothetical summation curves (4), these empirical excitatory and inhibitory gradients were algebraically summed, yielding the numerical values that are given in the left-hand graphs and plotted in the "derived" postdiscrimination gradients (PDG) on the right-hand side of Fig. 3.

The agreement between the shapes of the derived and actual relative PDG's was good for all three amounts of stimulus separation, with the exception of the discrepancy at S+ for the separation experiment of 30° (12). As a measure of the amount and direction of shift in distribution, the ratio of total scores on the right side of S+ to total scores on both sides of S+ was calculated for each actual and derived gradient. To avoid complications arising from negative values, a constant was added to every score in each derived gradient, so as to make the corresponding derived and actual gradients coincide at the minimum value in the actual gradient. These calculations revealed that there was only a minor shift to the right when S- was $\pm 90^\circ$ (57.6 percent of the total scores were on the right side of the gradient for the actual PDG and 55.5 percent for the derived PDG, as compared to 50.9 percent for the excitatory gradient), a larger shift to the right when S- was -60° (73.1 percent lay on the right for the actual PDG and 64.7 percent for the derived PDG), and a very large shift to the left when S- stimulus was $+30^\circ$ (19.3 percent lay on the right for the actual PDG and 24.2 percent for the derived PDG). The directions of these shifts and the rank orders of magnitudes of shifts in the three experiments were thus exactly the same for the actual and derived measures.

The above paradigm seems a promising framework for studying the empirical relations among excitatory, inhibitory, and intradimensional-discrimination gradients. Moreover, such gradients may replace the hypothetical or arbitrary ones often used to test gradient-interaction theories like that of Spence and Hull. The elegance and generality of this type of theory, which may be extended (13) to cover such phenomena as overtraining effects, errorless learning, peak-shift and stimulus-intensity dynamism, classical conditioning, and avoidance learning, seem sufficient rea-

sons for justifying thorough empirical tests. Perhaps more sophisticated mathematical transformations of the obtained excitatory and inhibitory gradients, instead of the simple relative measures used in Fig. 3, would yield even more accurate predictions of differential stimulus control after intradimensional training (14). In any event, the gradient-interaction approach seems a valuable way to analyze intradimensional-discrimination learning, and this study indicates the feasibility of a direct attack on some of the assumptions and implications of this type of theory.

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References and Notes

1. I. P. Pavlov, *Conditioned Reflexes* (Oxford Univ. Press, London, 1927).
2. K. W. Spence, *Psychol. Rev.* **44**, 430 (1937).
3. W. Kohler, *Gestalt Psychology* (Liveright, New York, 1929).
4. C. L. Hull, *A Behavior System* (Yale Univ. Press, New Haven, 1952), pp. 59-99.
5. D. A. Riley, *Discrimination Learning* (Allyn and Bacon, Boston, 1968).
6. H. S. Terrace, in *Operant Behavior: Areas of Research and Application*, W. K. Honig, Ed. (Appleton-Century-Crofts, New York, 1966), pp. 271-344.
7. An experimental chamber commercially produced by Lehigh Valley Electronics Co. was used. See E. Hearst, M. B. Koresko, R. Poppen [*J. Exp. Anal. Behav.* **7**, 369 (1964)], for relevant details concerning experimental method, apparatus, and equation of the brightnesses of the projected stimuli.
8. G. S. Reynolds, *ibid.* **4**, 289 (1961).
9. Space is not available in this report to discuss at length the data of phases 3 and 4. But in every experiment birds given preexcitation training in phase 1 (that is, group 1) learned the phase 3 discrimination more rapidly than birds given preinhibition training in phase 1 (that is, group 2). The same result has been obtained in subsequent studies in which phase 2 (generalization test) was omitted. This finding does not lend support to general theories of discrimination learning which emphasize error-elimination or inhibitory factors as being more important than excitatory factors.
10. See also H. Hanson [*J. Exp. Psychol.* **58**, 321 (1959)], for a study which tested these predictions along a visual-wavelength continuum; in that study, however, no direct determinations of inhibitory gradients were obtained.
11. H. S. Terrace, *Science* **154**, 1677 (1966).
12. In other words, "peak shift" was predicted for the 30° separation but was not obtained. However, T. M. Bloomfield [*J. Exp. Anal. Behav.* **10**, 361 (1967)] did observe more responding on a generalization test at -30° than at the positive stimulus of 0° in three of the five birds he trained with a negative stimulus of $+45^\circ$. This was a greater separation of positive and negative stimuli than in our 30° separation, and thus peak shift should have been even less likely in Bloomfield's experiment. The reasons for this discrepancy are not clear.
13. See, for example, H. S. Hoffman, in *Punishment and Aversive Behavior*, B. A. Campbell and R. M. Church, Eds. (Appleton-Century-Crofts, New York, in press); and E. Hearst, in *Fundamental Issues in Associative Learning*, N. J. Mackintosh and W. K. Honig, Eds. (Dalhousie Univ. Press, Halifax, in press).
14. Predictions based on algebraic summation of either absolute or relative gradients might be improved, and useful empirical knowledge might be gained, if the differential amount of time spent in phase 1 by the separate groups were somehow taken into account in further work. Because a discrimination criterion was

used here, the groups of birds inevitably differed in the average amount of time spent in phase 1, particularly in the experiment involving the difficult separation of 30°. Data concerning the effect of amount of training on simple excitatory or inhibitory gradients have been recently reported [E. Hearst and M. B. Koresko, *J. Comp. Physiol. Psychol.* **66**, 133 (1968); G. W. Farthing and E. Hearst, *J. Exp. Anal. Behav.*, in press].

15. Supported by PHS grant MH 12120. I thank G. W. Farthing, M. Koresko, L. Shallenberger, and C. Ebbe for advice and assistance.

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8 August 1968

Mosaic Unit Ruler

The sequence of ratios that Moore has observed (1) in the dimensions of ancient Greek and Roman floor mosaics (known to mathematicians as the Fibonacci numbers) might be incorporated more economically in a ruler marked only (in units of 1.197 cm) at 0, 1, 2, 5, 13, 34, and 89. The other observed lengths, except for the extra one of 18 units (21.6 cm), would then be included as the distances between different pairs of marks on the ruler. An alternative would be a shorter ruler, with marks at 0, 1, 3, 8, 21, and 55, in which case the length of 18 units would be included ($= 21 - 3$), while the length of 89 units (106.5 cm) would have to be obtained as the sum of 55 and 34, by placing the ruler twice.

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Reference

1. R. E. M. Moore, *Science* **161**, 1358 (1968).

7 October 1968

Holoclemensia Instead of Clemensia

It has been brought to my attention that *Clemensia*, the name I proposed (1) for an Albian (Middle Cretaceous) didelphid marsupial, is preoccupied by *Clemensia* Packard of the Lepidoptera (2). I therefore replace *Clemensia* Slaughter with *Holoclemensia* Slaughter, 1968.

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References

1. B. H. Slaughter, *Science* **162**, 254 (1968).
2. *Proc. Entomol. Soc. Philadelphia* **3**, 100 (1864).

21 October 1968