tissue homogenates is in progress to determine more about the nature of the variant LDH.

LINDA RILES

Department of Animal Genetics,
University College, London.

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PSYCHOLOGY

A General Theory for the Evolution of Intelligent Behaviour

THE problem of the evolution of intelligent behaviour has recently achieved publicity[1] in relation to work on the learning abilities of various vertebrates[2]. Over the past three years I have developed a general theory of the evolution of intelligence from, and within the framework of, an instinct system of Lorenz–Tinbergen type[3]. This theory is of wider scope than any which could be advanced on the basis of the present theories of learning; it can, it is felt, accommodate most of the 'learning theory' views; and it appears to provide a context for the understanding of a considerable variety of other phenomena. An extended account and discussion of this general theory of the evolution of intelligence is being offered for publication elsewhere—but a very brief preliminary account appears desirable, to stimulate interdisciplinary appraisal and discussion.

If a generalized and non-committal view of intelligent behaviour be adopted, namely, that its salient characteristic is adaptive variability, the evolutionary problem can be stated in terms of the generation and selection of this characteristic from out of the relative fixity and rigidity of a system of instinctive behaviour. Detailed analysis of what is involved brings to light three features or 'factors' which must be represented in the finally-produced 'intelligence'. There must develop: (1) a capacity not to respond (or to delay the response) to the 'releasers'[4] of responses which were previously normal, so as to allow the substitution of new kinds of response; (2) a dynamic 'memory store', 'knowledge' of the environment in relation to the individual animal, on the basis of which new responses can be elaborated; (3) an ability to abstract and generalize, to perceive similarities and differences, so that in the light of the past experience of the individual (2), the new variants of behaviour can be made adaptive as quickly as possible.

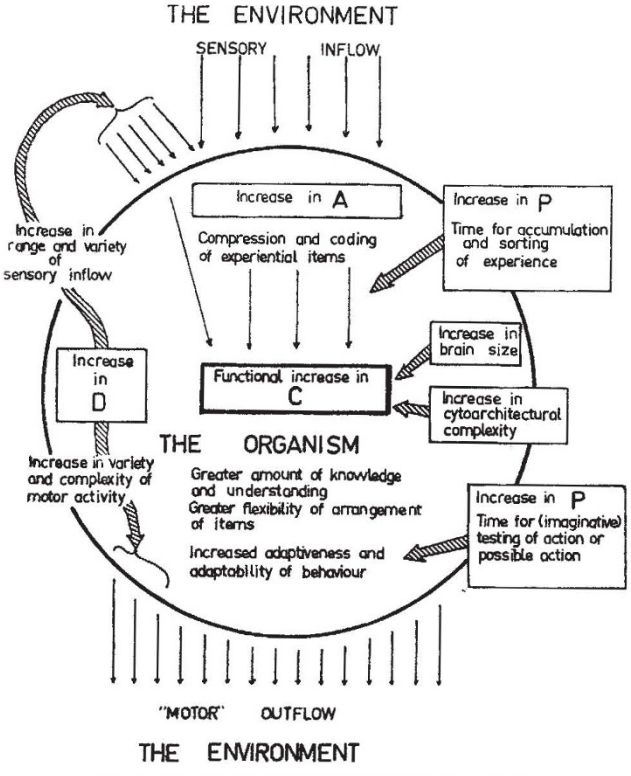

Fig. 1. Four-factor biological intelligence in evolution

These three features correspond remarkably with three factors isolated by Halstead[5] within 'biological intelligence'. The foregoing three features mentioned correspond to Halstead's *P*, *C*, and *A* factors respectively. Halstead's fourth, the *D* factor, is one which measures the efficiency of the individual's sensorimotor intercourse with the environment—and this must be under positive selection alike in 'intelligent' and in 'instinctive' animals. Halstead's approach was through the analysis of the behaviour-impairment of brain-injured humans; and the agreement between conclusions arrived at by very different routes is felt to constitute strong support for the view of intelligence which has emerged.

The Russells[6] have shown the relevance of Halstead's 'biological intelligence' to the differentiation between normal and pathological behaviour in humans. The concept of 4-factor biological intelligence developed severally by Halstead and myself is also illuminating with regard to present researches into personality differences among scientists[7], and into 'creativity' in humans[8]; and it provides a theoretical framework for the interpretation of some neurological experiments[9] and various other phenomena. Exploratory activity, and play, assume an enhanced significance; further discussions will be offered for publication elsewhere.

I am greatly indebted for encouragement and criticism in the development of this work to Dr. N. Tinbergen, and to my friends and colleagues, G. F. K. Naylor, M. C. Bleakly, M. J. Thorne, and D. Judge.

DAVID STENHOUSE

Department of Zoology,
University of Queensland, Brisbane, Australia.

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[2] See, for example, Bitterman, M. E., *American Psychologist*, **15**, 704 (1960).
[3] Tinbergen, N., *A Study of Instinct* (Clarendon Press, Oxford, 1951).
[4] Used in the broad sense of "total releaser situation", cf. Tinbergen, ref. 3 above.
[5] Halstead, W. C., *Brain and Intelligence* (Chicago University Press, 1947).
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[8] *Contemporary Approaches to Creative Thinking*, edit. by Gruber, H. E., Terrell, G., and Wertheimer, M. (Atherton Press, N.Y., 1962).
[9] See, for example, Ellen, P., and Wilson, A. S., *Experimental Neurology*, **8**, 310 (1963).

Effect of Foster-mothers' Strain and Pre-natal Experience on Adult Behaviour in Rats

THE examination of the effects of the experiences of one generation on the behaviour of their offspring is of intrinsic interest. It is also of importance in relation to experiments in both psychogenetics and the study of the effects of pre-natal environments. Experiments with rodents have shown that both the strain and the early experiences of foster-parents can affect the later behaviour of the offspring they rear. Thus Ressler[1] showed that the strain of the foster-parents of mice can affect the later exploratory behaviour of the fostered offspring. Such effects may be mediated by differences in parental behaviour towards the pups[2], and, since the behaviour of parent animals can be affected by their own experiences, the behaviour of an organism can thus be affected by the previous experience of the parents which rear it.

Denenberg and Whimbey[3] have shown that the weaning weights of rats and later their emotional defaecation scores in the open field were significantly influenced by the experiences their mothers had had as infants, and Ressler[4] that the visual exploration scores of offspring of mice, which had been reared by either one of two strains of foster-parents or by their biological parents.