

for five successive days. The second sample, representing conversational language, is the text of the British Broadcasting Corporation's radio serial "Mrs. Dale's Diary", also for five successive days. In both cases names of persons and foreign place names were excluded.

The analysis was made by a National-Elliott 405 electronic computer at the G.P.O.'s London Electronic Agency for Pay and Statistics (*Leaps*). Two programmes have been written. One gives digram frequencies, counts being printed for all possible digrams; letter frequencies and a word count are obtained as by-products. The second programme gives trigram frequencies; the printed results give counts only for those trigrams occurring in the sample analysed.

Tables 1 and 2 show respectively the digram frequencies of the two samples. Copies of the trigram results are available from us. With the material now at hand, words can be generated which are either zero-, first-, second- or third-order approximations to either written or spoken English.

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¹ Shannon, C. E., and Weaver, W., "The Mathematical Theory of Communication" (Univ. of Illinois Press, Urbana, 1949).

² Miller, G. A., "Language and Communication" (McGraw-Hill, New York, 1951).

³ Newman, E. B., and Gerstman, L. S., *J. Exp. Psychol.*, **44**, 114 (1952).

⁴ Pratt, F., "Secret and Urgent, the Story of Codes and Ciphers" (Robert Hale, Ltd., London, 1939).

A Possible Fundamental in the Behaviour of Young Nidifugous Birds

THE great output of papers over the past few years on the phenomenon of imprinting has recently been reviewed by Hess¹ and this has been brought up to date by Thorpe².

Although it seems that imprinting may not necessarily be irreversible, and in fact may not be very different from other types of learning^{3,4}, it is still convenient to define it as "the process whereby certain juvenile birds become psychologically fixed upon the parent during the first very few days after hatching". Analyses of processes in young nidifugous birds covered by this broad definition have shown that imprinting may occur in response to a parent-object moving away from the juvenile or to various other visual stimuli including 'retinal flicker'^{1,4,5}, or to various acoustic stimuli^{4,5}.

All such analyses, however, utilize juveniles hatched in incubators or by the normal female not under detailed observation, that is, the analyses begin after the first possible stimulus-response period, the time of actual hatching, is over. In other words, incubator-raised juveniles may be 'incomplete' with respect to an appetitive behaviour-consummatory act complex involving the parent bird, and normally hatched birds will be 'complete' in this respect. Such a difference in experimental material may well result in differences in response; an unknown variable may have been operative.

Results suggesting this have been obtained in the course of work on eider ducklings (*Somateria mollis-*

sima) in the Canadian arctic during the summers of 1958⁷ and 1959⁸. Twelve eider ducklings imprinted to myself in varying degrees have been raised naturally in the field to at least one week old. After this some were raised on prepared food, some 'escaped', and some died. Most of the observed behaviour patterns have been checked by comparison with wild eiders of the same age at the same time and place. On the authority of Haldane⁹, 20 randomly selected juveniles are regarded as enough for ethological statistical validity.

One of the most significant behaviour patterns observed is one which occurs immediately upon hatching. I propose to call this the 'brooding reflex' because it seems to be the mechanism whereby the newly hatched duckling orientates itself to the position of optimum warmth and mechanical protection beneath the female. It involves an active search by the duckling for a feeling of enclosure around the head or part of the head. In this way the duckling investigates its surroundings, the appetitive behaviour being a search for a space into which it can thrust its bill or head. Thus, a duckling a few seconds after hatching on my hand would actively follow my other hand once I had held its head between finger and thumb. A state of rest, or even of sleep, could be released in the ducklings merely by providing this contact stimulus on two sides of the head or bill. A higher degree of enclosure was even more significant, as long as the bird was warm and could breathe and wriggle. All the ducklings in my care showed this response to a constant degree, but more significant perhaps, is the fact that I found that I could release a similar quiescence in wild juveniles. To date, this response has been positive in every nidifugous juvenile I have handled including the imprinted eiders and three imprinted red-breasted mergansers (*Mergus serrator*), and varying numbers of wild juveniles of eider, old-squaw (*Clangula hyemalis*), Canada goose (*Branta canadensis*), ringed plover (*Charadrius hiaticula*), and purple sandpiper (*Erolia maritima*).

It seems that the 'brooding reflex' may be of widespread occurrence within the Anatidae, and even among nidifugous birds in general. Whether it is regarded as a conditioning immediately preceding imprinting, or as an integral part of the full imprinting process, it would appear to be a fundamental behaviour activity which has previously been overlooked.

Detailed results of these studies will be published in due course. The work was carried out with the financial support of a Carnegie Arctic Research Scholarship and field grants from the Banting Fund of the Arctic Institute of North America, and the physical assistance of Mr. C. W. Nicol, all of which I gratefully acknowledge.

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¹ Hess, E. H., *Science*, **130**, 133 (1959).

² Thorpe, W. H., *Ibis*, **101**, 337 (1959).

³ Thorpe, W. H., "Learning and Instinct in Animals", 116 (London, 1956).

⁴ Klopfer, P. H., *Ecology*, **40**, 90 (1959).

⁵ Fabricius, E., *Acta Zool. Fenn.*, **68**, 1 (1951).

⁶ James, H., *Canad. J. Psychol.*, **13**, 59 (1959).

⁷ Driver, P. M., *Arctic*, **11**, 191 (1958).

⁸ Driver, P. M., Ph.D. thesis (in preparation).

⁹ Spurway, H., and Haldane, J. B. S., *Behaviour*, **6**, 34 (1953).