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“Imprinting” in Animals

by Eckhard H. Hess

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“Imprinting” in Animals

When ducklings are hatched, the first moving object they see is usually their mother. They proceed to follow her. If they see another moving object, however, they follow it instead

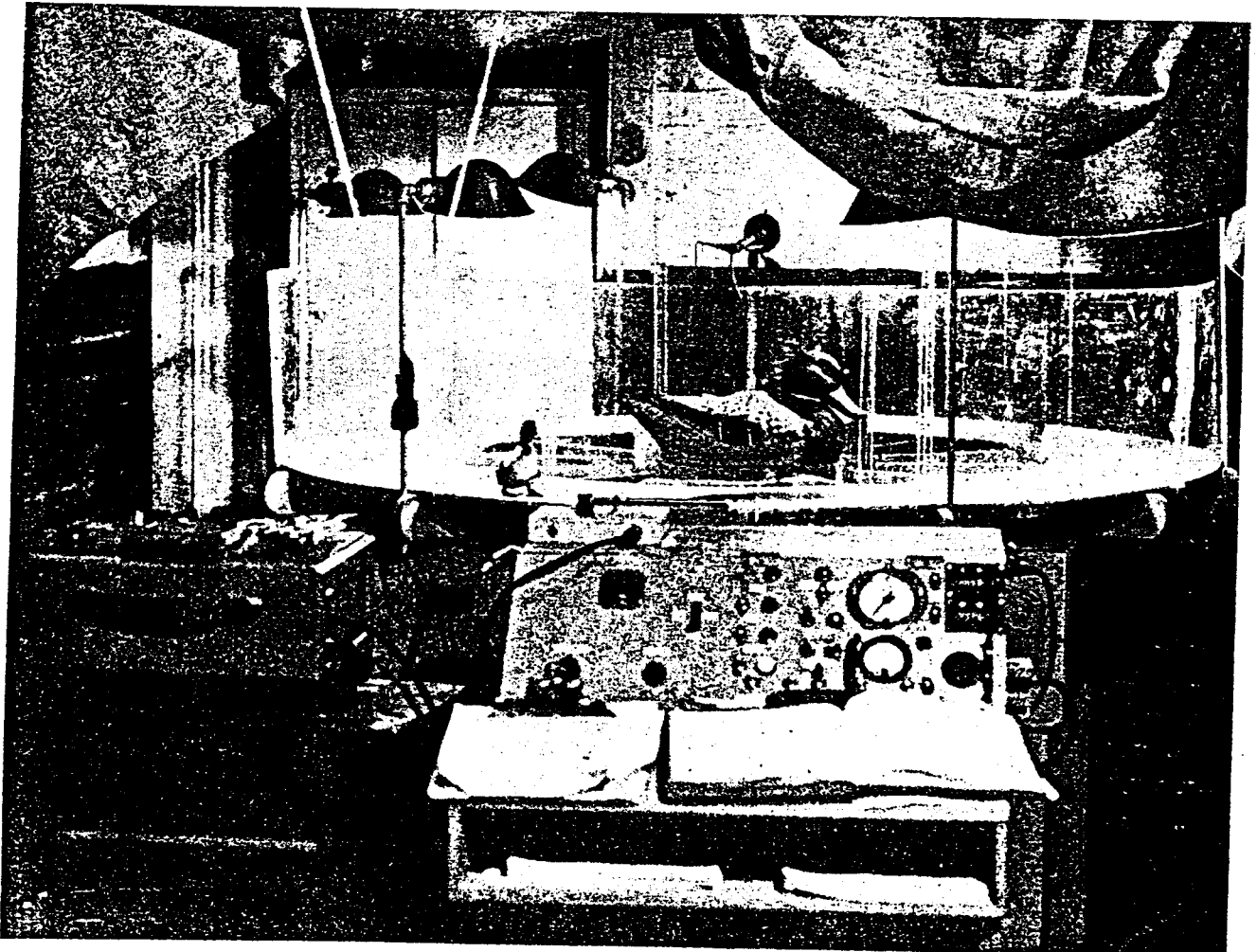
Eckhard H. Hess

What is meant by “imprinting” in animals? The best answer is to describe an experiment performed on geese by the Austrian zoologist Konrad Lorenz. On an estate near Vienna Lorenz divided a clutch of eggs laid by a graylag goose into two groups.

One group was hatched by the goose; the other group was hatched in an incubator. The goslings hatched by the goose immediately followed their mother around the estate. The goslings hatched in the incubator, however, did not see their mother; the first living thing they

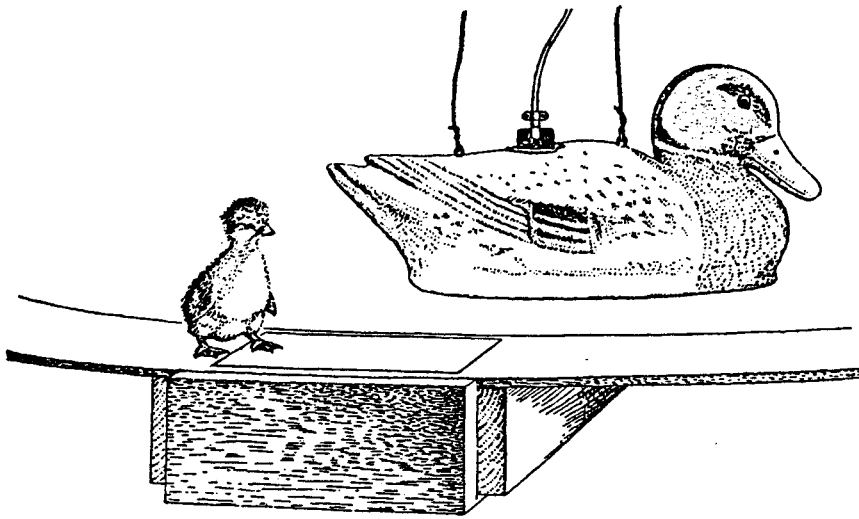
saw was Lorenz. They then followed Lorenz about the estate!

Lorenz now marked the two groups of goslings to distinguish them. He placed all the goslings under a large box, while the mother watched anxiously. When the box was lifted, the two groups of

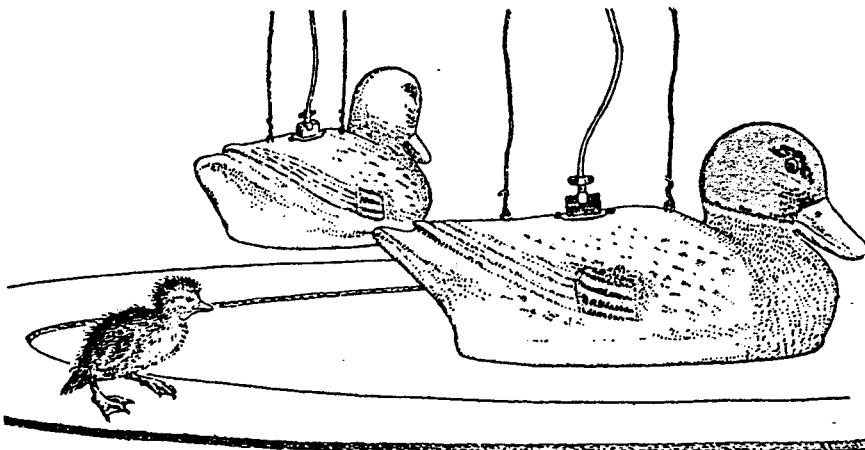


APPARATUS used by Hess and A. O. Ramsay in the study of imprinting consists primarily of a circular runway around which a decoy duck can be moved. In this photograph a duckling follows

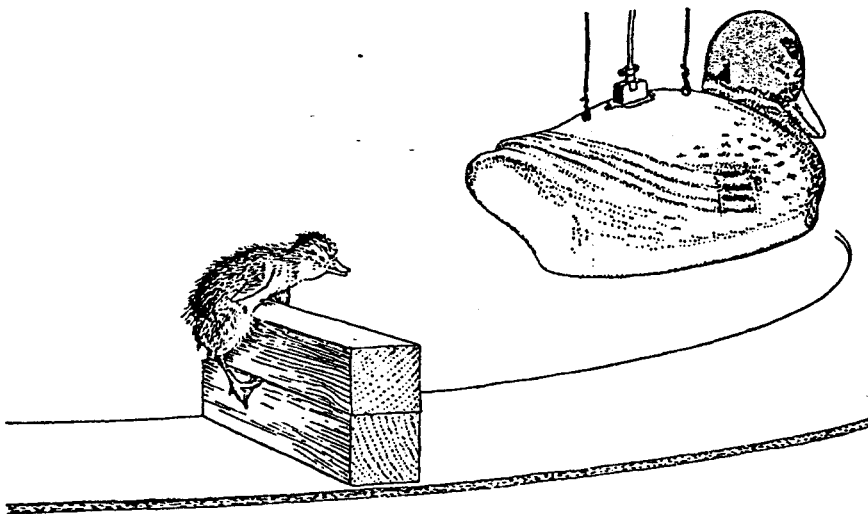
the decoy. In the foreground are the controls of the apparatus. At the top of the photograph is a cloth which is normally dropped so that movements of the experimenter will not distract the duckling.



DUCKLING IS IMPRINTED by placing it in the runway behind a model of a male duck which is wired for sound. Below the duckling is a trap door through which it is removed.



DUCKLING IS TESTED for imprinting by placing it between the male model and a female model which emits a different sound. If it follows the male, response is scored as positive.



DUCKLING SCALES AN OBSTACLE in the runway in an experiment to determine whether the effort it expends during imprinting is related to its score when it is tested.

goslings streamed to their respective "parents." Lorenz called this phenomenon, in which an early experience of the goslings determined their social behavior, "imprinting." Although earlier investigators had observed the effect, he was the first to name it and to point out that it appeared to occur at a critical period early in the life of an animal. He also postulated that the first object to elicit a social response later released not only that response but also related responses such as sexual behavior.

Students of behavior generally agree that the early experiences of animals (including man) have a profound effect on their adult behavior. D. O. Hebb of the University of Montreal goes so far as to state that the effect of early experience upon adult behavior is inversely correlated with age. This may be an oversimplification, but in general it appears to hold true. Thus the problem of the investigator is not so much to find out *whether* early experience determines adult behavior, but rather to discover *how* it determines adult behavior.

Three statements are usually made about the effects of early experience. The first is that early habits are very persistent and may prevent the formation of new ones. This, of course, refers not only to the study of experimental animals but also to the rearing of children. The second statement is that early perceptions deeply affect all future learning. This concept leads to the difficult question whether basic perceptions—the way we have of seeing the world around us—are inherited or acquired. The third statement is simply that early social contacts determine adult social behavior. This, of course, is imprinting.

Although imprinting has been studied mainly in birds, it also occurs in other animals. It has been observed in insects, in fishes and in some mammals. So far as mammals are concerned the phenomenon appears to be limited to those animals whose young are able to move about almost immediately after birth. For example, imprinting has been described in sheep, goats, deer and buffalo. For better or worse these observations have not been made under controlled laboratory conditions. One exception is a study begun in our laboratories at the University of Chicago. One of our students has observed that imprinting appears to occur in guinea pigs. Our work has dealt mainly, however, with imprinting in birds.

Lorenz and other European workers

have shown that a variety of birds are most easily imprinted during the first day after they are hatched, and that the birds will follow not only other animals but also inanimate objects. In this country A. O. Ramsay of the McDonogh School in McDonogh, Md., succeeded in making young Canada geese and mallard ducklings follow a small green box containing an alarm clock. Some ducklings and goslings responded to a football. In the early 1950s I met Ramsay and we decided to begin a cooperative study of imprinting under laboratory conditions. Among our goals were the following. What is the critical age at which imprinting occurs? How long must young birds be exposed to the imprinting object in order for them to discriminate between it and similar objects?

The subjects used in the experiments described here were mallard ducklings. We were fortunate in that our laboratory in Maryland had access to a small duck pond in which we could keep relatively wild mallards. The birds laid their eggs in nesting boxes, so the eggs could be regularly collected and hatched in laboratory incubators. Our experimental apparatus consisted of a circular runway about five feet in diameter and 12 inches wide, the walls of which were made of transparent plastic. Our imprinting object was a model of a male mallard duck, of the sort used by duck hunters as a decoy. The model was suspended from a motor-driven arm pivoted at the center of the apparatus; thus it could be moved around the runway at various speeds. Inside the model was a loudspeaker through which tape-recorded sounds could be played.

After the mallard eggs were collected, they were placed in a dark incubator. When the young birds were hatched, they were kept in individual cardboard boxes so that they would have no visual experience until they were put into the imprinting apparatus. The boxes were then kept in a brooder until we were ready to work with the birds. After each duckling was exposed to the imprinting object (the decoy duck) in the apparatus, it was automatically returned to its box by means of a trap door in the floor of the runway. The bird was then lodged in another brooder until it was to be tested for the imprinting effect.

The imprinting itself was accomplished first by placing the young mallard in the runway of the apparatus about a foot away from the decoy. As the bird was released, the loudspeaker inside the decoy was made to emit a

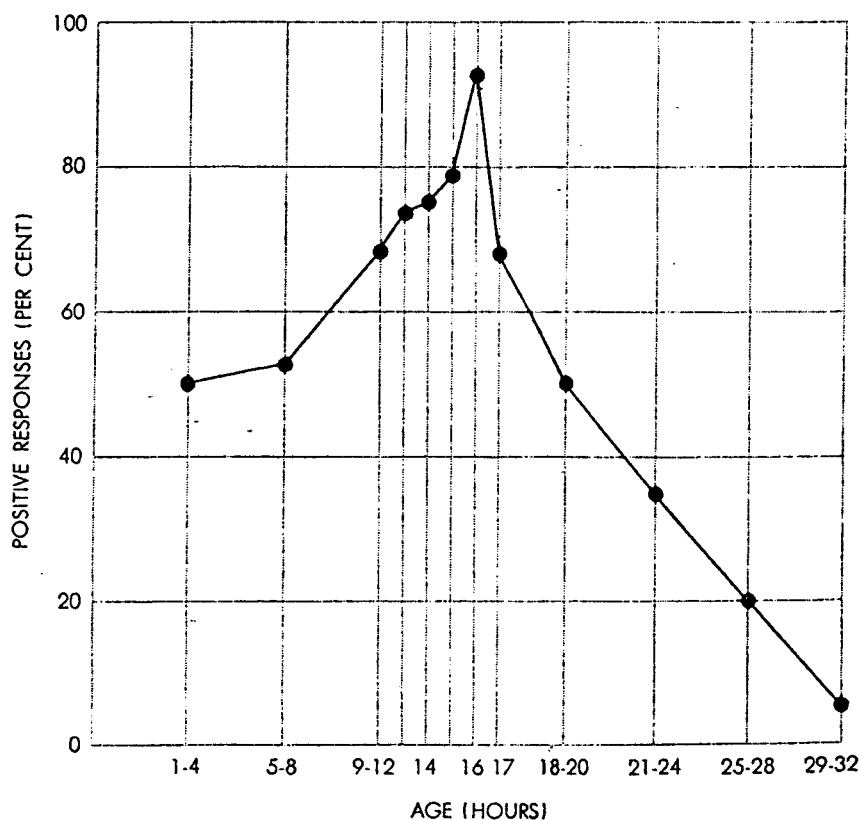
human rendition of the sound "GOCK gock gock gock gock," and after a short interval the decoy was moved around the runway. The imprinting period, during which the duckling followed the decoy, usually lasted 10 minutes. We can also imprint ducklings with a silent object, or even with sound alone. In one experiment we tried to imprint ducklings with the "gock" sound while they were still in the egg. This effort was unsuccessful.

The bird was tested for imprinting by releasing it between two decoys four feet apart. One decoy was the male model with which the duckling had been imprinted; the other was a female model which differed from the male only in its coloration. One minute was allowed for the duckling to make a decisive response to the silent models. At the end of this time, regardless of the duckling's response, sound was turned on in both models. The male model made the "gock" call; the female emitted the sound of a mallard duck calling her young. This latter sound was a recording of a real female. Four test situations were run off in sequence: (1) both models stationary and silent; (2) both models stationary and calling; (3) male stationary and female moving, both calling; (4) male stationary and silent, fe-

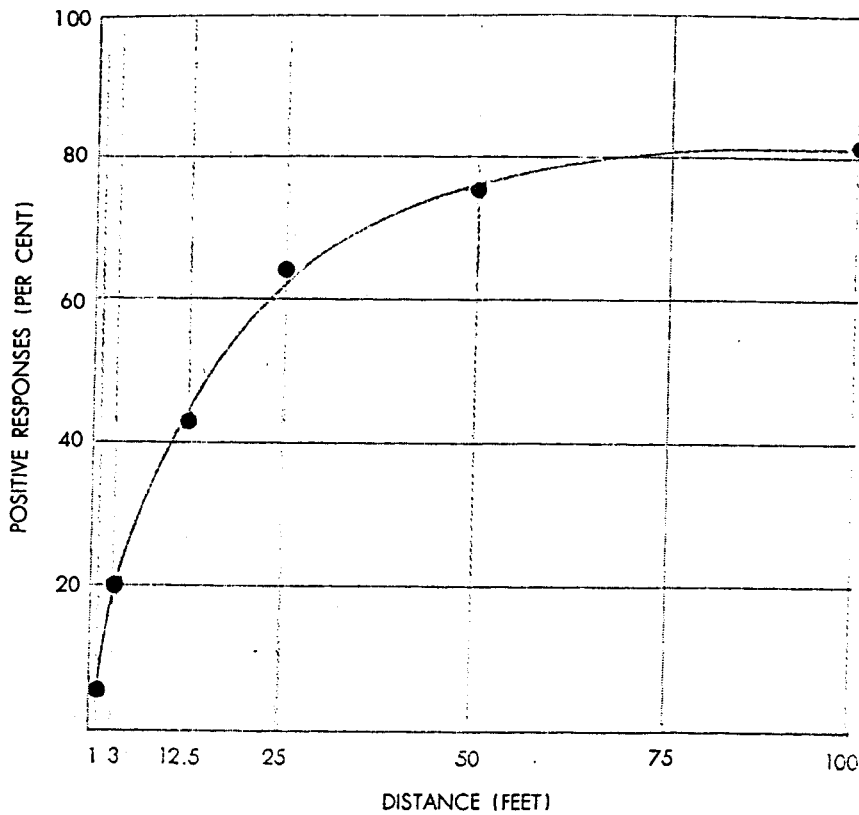
male moving and calling. Each bird was scored according to the percentage of its positive responses, *i.e.*, the number of times it moved toward the male model as opposed to doing something else.

To determine the age at which an imprinting experience was most effective we imprinted our ducklings at various ages after hatching. In this series of experiments the imprinting experience was standard: it consisted of having the duckling follow the model 150 to 200 feet around the runway during a period of 10 minutes. It appears that some imprinting occurs immediately after hatching; however, only those ducklings imprinted between 13 and 16 hours after hatching consistently made a maximum score [see chart below].

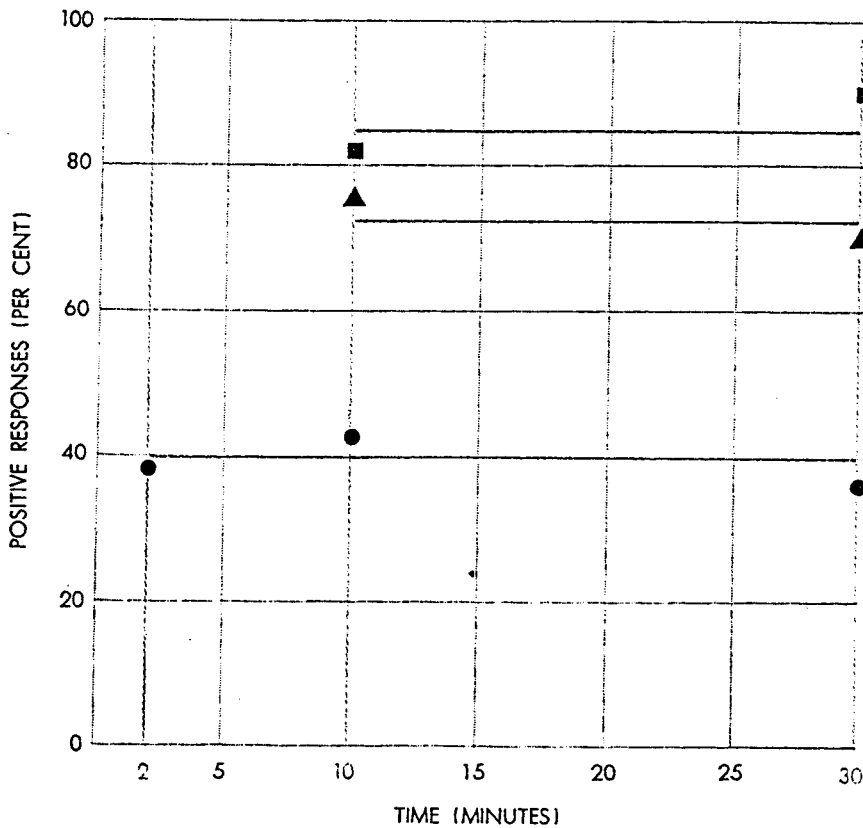
To answer the question how long the imprinting experience must last in order to be most effective we varied not only the time during which the duckling was exposed to the model but also the distance traveled by the duckling as it followed the model around the runway of our apparatus. We exposed groups of ducklings to the model for the same length of time (10 minutes), but during that time moved the model at different speeds so that the ducklings in each group moved a different distance (1,



CRITICAL AGE at which ducklings are most strongly imprinted is reflected by this curve. Each black dot on the curve is the average test score of ducklings imprinted at that age.



DISTANCE TRAVELED during imprinting affected the scores of ducklings as indicated by this curve. The farther the ducklings had traveled, the more strongly they were imprinted.



TIME ELAPSED during imprinting had little effect on the scores. The squares represent ducklings which had traveled 100 feet during imprinting; triangles, 50 feet; dots, 12.5 feet.

12½, 25, 50 and 100 feet). All the ducklings were imprinted between 12 and 17 hours after hatching. The results showed that at distances up to 50 feet the strength of imprinting increased with the distance traveled [see chart at top of this page].

We now allowed other groups of ducklings to travel the same distance, but over different periods of time. One turn around our runway is 12½ feet; a duckling can walk this distance in something less than two minutes. We moved the decoy so that groups of ducklings made one turn around the runway in 2, 10 and 30 minutes. The scores of these animals were essentially identical [see chart at bottom of this page]. Moreover, there was no significant difference between the scores of ducklings which followed the decoy 100 feet in 10 minutes and those which traveled the same distance in 30 minutes.

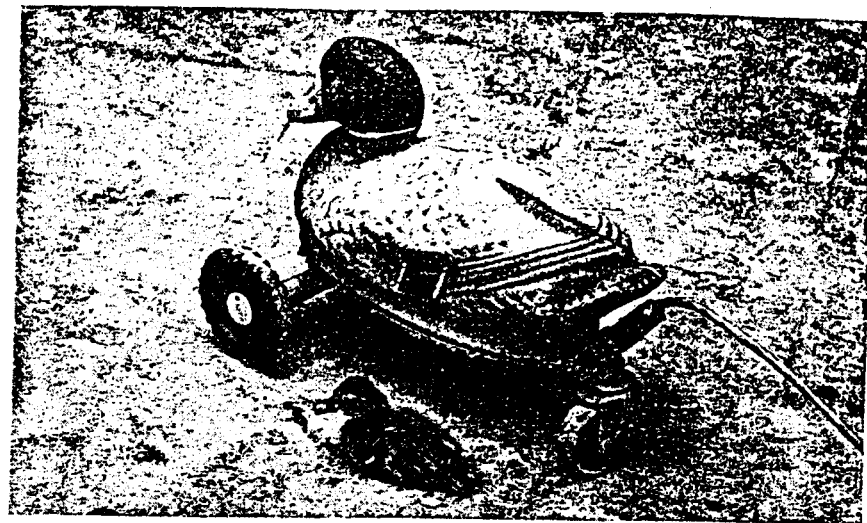
In other words, the strength of imprinting appeared to be dependent not on the duration of the imprinting period but on the effort exerted by the duckling in following the imprinting object. To confirm this notion we tried two supplementary experiments. In the first we placed four-inch hurdles in the runway so that the ducklings not only had to follow the model but also had to clear the obstacles. As we suspected, the birds which had to climb the hurdles, and thus expend more effort, made higher imprinting scores than those which traveled the same distance without obstacles. In the second experiment we allowed the duckling to follow the decoy up an inclined plane, with similar results. After further experiments we came to the conclusion that we could write a formula for imprinting: the strength of imprinting equals the logarithm of the effort expended by the animal during the imprinting period.

Now that we had this basic information, we began to explore other aspects of imprinting. We had been puzzled by the fact that the imprintability of ducklings rapidly declines soon after they are 16 hours old. We had noticed, as had other workers, that ducklings develop their first emotional response when they are 16 to 20 hours old. This response is an avoidance or fear of moving objects. Twenty-four hours after hatching almost 80 per cent of the ducklings exhibit this fear; the proportion increases to 100 per cent at about 32 hours. Does this fear response knock out imprinting?

At the time we were reflecting on this

question the tranquilizing drugs had just been introduced, and it occurred to us that these drugs which reduce fear and anxiety might solve our problem. We administered meprobamate (Miltown) to 24-hour-old ducklings; their fear response was indeed reduced. We then imprinted the drugged birds 26 hours after hatching. Ducklings 26 hours old are of course imprinted very weakly, but we were surprised that the imprinting scores of these animals were even lower than normal. In other words, eliminating fear did not improve imprintability. Later we found that the tranquilizer also interfered with the imprinting of young mallards at an age when they were normally most imprintable. So far our best conclusion is that meprobamate, being a muscle relaxant, nullifies the effectiveness of the imprinting experience by relaxing muscular tension. It is also possible that in the imprinting process some degree of anxiety is necessary. This anxiety, from an admittedly human viewpoint, may merely be the fear of being left alone; the duckling might thus tend to follow the imprinting object as it moved away. We are continuing our study of these drugs because we feel that it may not only shed some light on the mechanism of imprinting but also may give us valuable information about the action of the drugs themselves.

We have also considered the genetic side of imprinting. We have kept ducklings which were highly imprintable and bred them separately from ducklings which showed very little imprinting response. Significant differences appeared even in the first generation: the offspring of imprintable parents were easily imprinted; those of less imprintable par-



REMOTE-CONTROLLED DECOY was used by Hess and his colleagues in other imprinting experiments. Here both decoy and duckling move about freely rather than on a runway.

ents were difficult to imprint. We are also following up those animals which have had experimental imprinting experiences to determine what influence, if any, these experiences have on their adult behavior. So far the results are inconclusive, but they do suggest that experimental imprinting of mallards affects their adult behavior, particularly with respect to courtship patterns.

We have performed imprinting experiments not only with mallards and, as indicated earlier, guinea pigs, but also with other kinds of ducks, several varieties of geese, with sheep, turkeys, pheasants, quail and chickens. We have had some success in imprinting certain breeds of chicks (mainly Cochin bantams and Seabright bantams), but in general domestic fowl cannot be as clearly imprinted as wild birds.

What does all this have to do with human behavior? Of course it is not really necessary to relate our work to such behavior; it is interesting and important in its own right because it tells us something about the way an organism adapts itself to the world. We do feel, however, that the work has some implications which are relevant to humans. It has long been known, for example, that in order for a child to develop normally it must have a certain amount of attention and handling during a critical period of its infancy. This period is doubtless not as sharply defined as the imprinting period in birds, but it may lie within the first six months of life. Jere Wilson of our group is studying the smiling response of infants in an effort to get at some aspects of human behavior which may involve imprinting.

The Author

ECKHARD H. HESS is associate professor of psychology at the University of Chicago. The work on imprinting which he carries on there is a part of his larger campaign of research on the experience of infant animals and how it affects their behavior. Hess was born in Germany, graduated from Blue Ridge College and acquired M.A. and Ph.D. degrees from the Carnegie Institution of Washington's Department of Embryology, located in Baltimore.

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I. SUMMARY

On an estate near Vienna, Konrad Lorenz divided a clutch of eggs laid by a graylag goose into two groups, one of which was hatched by the goose herself, the other in an incubator. The goslings hatched by their mother followed her around the estate. The goslings in the other group, however, did not see their mother; the first moving thing they saw was Lorenz, and they followed him. Lorenz called this phenomenon, in which an early experience determined subsequent social behavior, "imprinting." Students of behavior have long recognized the profound effects that early experience can have on adult behavior; so the investigator needs to determine, not *whether* such effects occur, but rather *how* they occur. In this vein, Hess has attempted to answer two major questions concerning the imprinting phenomenon. First, what is the critical period during which imprinting can occur? Second, what kind of exposure must young birds have to the imprinting object in order for them to discriminate between it and similar objects?

To answer the first question, Hess subjected ducks to a standard imprinting experience at various ages after hatching; the young ducks were allowed to follow a moving model duck for 10 minutes. The results of the subsequent test, where the ducklings had to choose between the model with

which they had been imprinted and another, indicated that some imprinting occurred immediately after hatching. However, only those ducklings imprinted between 13 and 16 hours after hatching consistently made a maximum score. To answer the second question, Hess exposed groups of ducklings to the model for the same length of time, but during that time the model moved at different speeds, so that different groups of ducklings followed it for different distances. The results showed that for distances up to 50 feet the strength of imprinting increased with the distance traveled. On the basis of this finding, Hess hypothesized that the strength of imprinting is related to the effort expended in following the imprinting object. Several additional observations confirmed this view. Variations in the amount of time that the imprinting lasted had no effect as long as the distance traveled was the same. Hurdles placed in the pathway of the duckling during imprinting increased the effort involved and thus the strength of imprinting; and making the duckling follow the model up an inclined plane had the same effect. Thus, it appears that the effort which is expended by the young animal during imprinting and the interval after hatching when the imprinting occurs are two important factors determining the strength of the imprinting.

II. GLOSSARY

critical period — a time during the life of an organism when certain responses must be learned if they are to be learned at all.

imprinting — the young of some species follow during their infancy any moving object which is present during the critical period shortly after birth.

III. ESSAY STUDY QUESTIONS

1. What contributions did Lorenz make to the study of imprinting?
2. What three statements are usually made about the effect of early experience?
3. In what animals does imprinting occur?
4. Describe Lorenz's experiment on imprinting.
5. What is the critical age at which imprinting occurs? Describe the experiment designed to answer this question.
6. The strength of imprinting depends on the effort expended. Explain and offer experimental support for this statement.
7. What effect do tranquilizing drugs have on imprinting?