IMPRINTING, WITH SPECIAL REFERENCE TO ANXIETY

by

P. JOHN DILLON
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Department of Psychology

The University of British Columbia, Vancouver 8, Canada.

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ABSTRACT

The general purpose of this research was to investigate the behaviour of newly-hatched chickens during their first few days of life. Various degrees of social isolation and of approximation to a normal environment were used, and special note was taken of their behaviour which might reflect the presence of anxiety in the chicks.

With these observations as a base-line, the behaviour of comparable chicks in a typical imprinting situation was then examined, again with special reference to behavioural indices of anxiety. Based on both sets of observations, an analysis of the psychological processes underlying the behaviour in the imprinting situation was made.

There were several reasons for proceeding in this manner:

(1) Observation of chicks in a non-experimental situation provides knowledge of their usual behaviour, and thereby reduces the probability that subsequent interpretations will be artificial, and that subsequent conclusions regarding their behaviour will be erroneous.

(2) Unless record is made of the usual behaviour of chicks in a non-experimental situation, it is not possible to assess the effect of any experimental procedure.

(3) Reports in the literature have usually indicated that behaviour in the imprinting situation is characterized by fairly stereotyped following of a moving object. Preliminary observations and discussion suggested that such reports were entirely too narrow, and that other behaviour in the situation had been neglected. This other behaviour was felt to be as significant as the following behaviour customarily reported.

Both sets of observation provided abundant evidence that the behaviour of the chicks in the imprinting situation was not fundamentally different from their behaviour in a less experimental environment, and confirmed the belief that the behaviour in the imprinting situation was not as rigid and narrow as usually reported.

The several theories of imprinting were examined from this wider point of view, especially that of Howard Moltz (1960). Certain inconsistencies in Moltz's theory were discussed, and some alternative ideas, mainly concerning anxiety novelty and habituation, were introduced.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>REVIEW OF THE RELEVANT LITERATURE, AND GENERAL STATEMENT OF THE PROBLEM</td>
</tr>
<tr>
<td>II</td>
<td>METHODS AND PROCEDURES</td>
</tr>
<tr>
<td></td>
<td>(a) Outside the Imprinting Situation</td>
</tr>
<tr>
<td></td>
<td>(b) In the Imprinting Situation</td>
</tr>
<tr>
<td>III</td>
<td>RECORD OF OBSERVATIONS</td>
</tr>
<tr>
<td></td>
<td>(a) Outside the Imprinting Situation</td>
</tr>
<tr>
<td></td>
<td>(b) In the Imprinting Situation</td>
</tr>
<tr>
<td>IV</td>
<td>DISCUSSION OF THE OBSERVED BEHAVIOUR, WITH REFERENCE TO THEORIES OF IMPRINTING</td>
</tr>
<tr>
<td>V</td>
<td>SUMMARY AND CONCLUSIONS</td>
</tr>
<tr>
<td></td>
<td>REFERENCES</td>
</tr>
<tr>
<td>Table No.</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>1</td>
<td>List of groups observed outside the imprinting situation.</td>
</tr>
</tbody>
</table>
CHAPTER I

REVIEW OF THE RELEVANT LITERATURE AND GENERAL STATEMENT OF THE PROBLEM

A. BACKGROUND

Reports that chickens, ducks, geese, and other birds will follow a moving object other than their natural parents, within the first few hours or days after hatching, have appeared in scientific journals and quasi-scientific magazines since the latter half of the last century (Spalding, 1873; James, 1892; Craig, 1908; Heinroth, 1910). That such a thing happens is almost certain to have been known well before that. Since psychology as an experimental science had hardly begun to establish itself at the time of these first reports, it is not surprising that little systematic investigation of the observed phenomenon was performed, and since, for the most part, young birds were observed following their parents, and orienting much of their early behaviour towards them, interest lay more in the presumed instinctiveness of the almost universally observed parent-following than in those cases where the objects followed were other than the parents. However, it is precisely because the birds soon after hatching can regularly be shown to follow these other objects—without receiving any of the usual reinforcers of experimental psychology—that interest in the phenomenon now lies in its possibility as a case which requires learning theory, the very core of psychology, to be seriously revised.
The basic task of learning theory is to determine the necessary and sufficient conditions for what is called learning to occur. To do this it must establish a definition of what it means when it uses the term learning. These two problems are closely interwoven, if not formally, then in the experimental procedures and the reasoning of those who are concerned with them—witness the perennial controversy over latent learning, and the tremendous divergence between S - R, S - S, and Gestalt theorists. Even if all sides were to agree in labelling the process implied by the term 'perception' a response—which itself has been a major stumbling-block for many years—the contention would hardly be reduced, for, while some theorists believe that the perception of certain stimulus-complexes is a sufficient condition for learning to occur, others hold that some form of reinforcement must accompany the response, (in this case the perception), if learning is to occur. Stemming from this basic difference, several lines of investigation and further discussion have developed. Social reinforcers, secondary rewards, fractional-anticipatory-goal-responses, and the like, have been advanced on one side to account for what had been put forward as cases of learning-without-reinforcement, and on another side it was suggested that some responses were self-reinforcing. Guthrie's suggestion that the function of rewards in certain escape situations was simply to remove the animal from the situation (and so to stop him making responses in that situation)—thereby preserving the
last response made, which was, of course, the one which made the exit possible—has always been a thorn in the flesh of reinforcement theorists. Again, the data on avoidance-conditioning have been arraigned against reinforcement theories of learning, and, more recently, much attention has been given to the behaviour of animals placed in a novel environment, in the absence of conventional reinforcers, and to their behaviour on subsequent exposures to the same environment. From the point of view of learning theory, three things have become very clear as the result of all this: firstly, that the earlier conceptions of reinforcement have become so extended, and applied in such a wide variety of ways, that it is questionable whether, from an overall viewpoint, the term has much left in it; secondly, that the necessary and sufficient conditions for learning to occur have not been agreed upon; and thirdly, that no adequate definition has been formulated of the term learning. (As an illustration of this situation, see McConnell and Jacobson, 1962, pages 42 and 46 in particular.)

Even without venturing into the neurophysiology of the matter, only some of the problems have been mentioned, and this state of affairs should be borne in mind in discussing imprinting phenomena and processes, and in investigating and theorizing about the relationship of these to learning and to instinct, as will be done later.
The position of instinct theorists, both ancient and modern, must necessarily be considered before concentrating on what has been established concerning imprinting. The neonate organism has been the focus of attention here for the supposedly sufficient reason that in the first observable items of behaviour, one must surely be witness to the expression of pure nature, untrammelled by the effects of experience. Two major difficulties have almost always been admitted, that the organism develops in the foetal (or equivalent) stage, and that certain items of behaviour do not appear until the organism is relatively old (e.g., courtship and reproductive behaviour), and then they appear at a given age, and in a stereotyped form both of which are common to the species, even though some members may have been reared in very different environments from others. Although the problem of the relation of prenatal and later maturational behaviour to the first behaviour of the neonate organism, and to the environment, has been admitted in the past, it is only recently that in this very problem has been found the key to the fallacious instinct-versus-environment, or nature-versus-nurture dichotomy. Lehrman (1953) has dealt probably the most incisive blow to the traditional dichotomized outlook, and it is a tribute to the scientific integrity of the latter-day instinctivists, the Ethologists, that they have recognized the meaningfulness of his criticisms, and have since formulated their theories in such a way that the
problems which were unseen, ignored, or glossed-over, have now been taken into account. (e.g., Lorenz, 1954; Tinbergen, 1954.) Hebb, too, has been concerned to bring out the difficulties involved here (1953, 1958). Before discussing Lehrman's position, however, it is well to consider some opponents in the traditional nature-nurture controversy.

McDougall's instinct theory (1923, for example) may be set up as the prime example of the 'nature' position. According to McDougall there are numerous instincts which are given expression in much, if not most, of an organism's behaviour. In other words, observable behaviour at any given stage results not from the past experiences of the organism, and from what it has learnt in and from those experiences, but rather from specific inborn instincts. It is not denied, of course, that a reasonably adequate environment is necessary for these instincts to operate, just as an adequate environment is necessary for the physical structures and characteristics of the organism to develop, but the rôle of the environment is seen as essentially that of providing a medium in which both the physical features and the behavioural features will be manifested. A partial list of these instincts reads as follows:

a) The parental or protective instinct,
b) The instinct of combat,
c) The instinct of curiosity,
d) The food-seeking instinct,
e) The instinct of repulsion, and so forth (pp. 130-165).

It will be seen that these are not behavioural items in a molecular sense, but rather are molar forms, or classes of behaviour. Training and experience can operate within these classes influencing the means adopted to achieve the particular end—for example, it may be the custom in some parts to duel rather than to use fists or gloves, and hence the instinct of combat would find its expression in the former rather than the latter fashion—but the instincts provide the urge to action, or they are, in McDougall's words, the "springs of energy" (p. 105). The main difficulty with such a theory is brought out when the instincts become numerous (as they did in the case in question), for then it becomes apparent that whatever the organism does, and whatever it does not do, are both nothing but the expression of the respective instincts—to cite the much used example: if he twiddles his thumbs it is the "thumb-twiddling" instinct, while if he does not twiddle his thumbs, it is the "thumb-not-twiddling" instinct, and so on.

Now, although McDougall's list of instincts refers to CLASSES of behaviour, essentially the same criticism can justly be levied against it, on two grounds, firstly, because there is implicit in the discussions of the various instincts, reference to, or a meaning which includes, specific molecular behavioural
items or units, especially with regard to the lower animals. This probably stems, in the first instance, from the necessary condition that structure limits function, but whatever its raison d'être, its presence is felt continuously; secondly, because of the very fact that the instincts listed refer to classes of behaviour, the determination of the molecular units which are subsumed within the classes becomes so subjective and personalized that if each item is taken separately, it would be difficult to assign it to a unique class, hence one has to look for a criterion of assignment beyond the behaviour of the organism. To some theorists of philosophical bent this has been perfectly acceptable, but McDougall insists that the definition of each instinct (i.e., of each class) lies in its motor expressions (p. 118), which accordingly justifies the second criticism above.

At the extreme opposite viewpoint was Kuo, who entitled one of his papers (1924), "A Psychology without Heredity," and who provided much experimental evidence in support of his position (e.g., 1930; 1932). His argument is well summarized in this quotation (1930, p. 33):

In other words, the kinds and range of potential responses of an organism are determined by its bodily size, and especially its bodily make-up or organismic pattern, (he stresses that he does not mean neural pattern, P. J. D.), while its actual responses are determined by its life history. Given an organismic pattern, its behavior can be modified at will by manipulating its life conditions.
An important point to note is that by life history Kuo means from fertilization to death, not from birth to death. In a passage immediately preceding the one just quoted he says, (referring to cats whose behaviour with respect to rats he had been investigating; p. 33):

its behavior is being modified from the moment of fertilization to the point of death, and is modified according to the resultant forces of environmental stimulation, intra-organic as well as extra-organic.

In the same paper he asks: (p. 33):

Have the cat and tiger any instincts? Does the chimpanzee possess any insight? Is the cat's behaviour towards the rat hereditary or learned through trial and error, or by imitation? To me all such questions are useless as well as meaningless.

This is Behaviourism in the Watsonian tradition which, with varying degrees of re-interpretation and/or damping, is implicit in much of present-day psychology. His disturbance at the superficiality of the arguments and investigations of those who were concerned to enumerate and demonstrate the instincts of man or other animals can be felt in this last quotation from the same source: (pp. 34-35):

The point I am here making is that the mere proof or disproof of an instinct, i.e., action which can be performed without learning, the mere experiments on trial and error learning and the mere test to show the presence or absence of insight or intelligence and imitation will not lead us anywhere.
We need to know the potential range or repertory of activities of a given species. We need to know the physiological and genetic or developmental aspects of each behaviour. The behaviour of an organism is a PASSIVE affair, (Kuo's emphasis). How an animal or man will behave in a given moment depends on how it has been brought up and how it is stimulated. Without sufficient knowledge of the physiology of behaviour and of the behaviour history of the organism, prediction would be impossible. Our study shows that kittens can be made to kill a rat, to love it, to hate it, to fear it, or to play with it: it depends on the life history of the kitten. In the future with more refined methods, with more thorough investigation in this direction, and with more knowledge of the physiology of the cat's behaviour, we should be able to predict in mathematical terms how a given cat will react to a given rat at a given moment. Our behaviour researches in the past have been in the wrong direction, because INSTEAD OF FINDING HOW WE COULD BUILD NATURE INTO THE ANIMAL, WE HAVE TRIED TO FIND NATURE IN THE ANIMAL, (Kuo's emphasis).

The comparison between the ideas of McDougall and Kuo throws one aspect of the controversy into sharp relief. To compare the ideas of Lorenz (1937) and Moltz (1960) on imprinting will illustrate how, even up to the present day, the conceptual dichotomy between instinct and learning persists despite the arguments, investigations, and pleas of many who see the fallaciousness and emptiness of such a division. Lorenz has more recently modified his earlier position on a number of counts, largely due, as mentioned earlier, to the criticisms of Lehrman, which will be discussed in a moment, and to some
recent experimental evidence which indicates that some of the characteristics of imprinting suggested by Lorenz are not as clear-cut as was thought. These too will be referred to later. Since, however, this contrast is intended mainly to provide the background to which investigations of imprinting belong (including the one reported here), as well as opening the discussion of imprinting itself, and further, since Lorenz's earlier writings express the spirit of the Ethologists' approach to such matters, these early writings will be quoted here in contrast to Moltz's apparently different viewpoint.

Lorenz (1937) claims that imprinting differs from learning in four respects: (pp. 249-251):

1. The process is confined to a very definite period of individual life, a period which in many cases is of extremely short duration; ....

2. The process, once accomplished, is totally irreversible, so that from then on, the reaction behaves exactly like an 'unconditioned' or purely instinctive response. This absolute rigidity is something we never find in behaviour acquired by associative learning, which can be unlearned or changed, at least to a certain extent.

3. The process of acquiring the object of a reaction is in very many cases completed long before the reaction itself has become established, ....

4. In the process of imprinting, the individual from whom the stimuli which influence the conditioning of the reaction are issuing, does not necessarily function as an object of this reaction.
Moltz (1960), on the other hand, contends that imprinting consists of two learning processes, operating on different exposures to the experimental situation (p. 305):

It is assumed that during the critical period...(classical) conditioning of...low-anxiety reactions occurs simply by virtue of their association with the object, and does not in any way depend upon reinforcement. However, as a result of this conditioning the object acquires the capacity to function as a reinforcer, henceforth mediating new learning. Specifically, it is assumed that when anxiety is subsequently aroused, any response instrumental in bringing the animal into contact with the familiar object will be closely followed in time by anxiety reduction due to the previously acquired capacity of the object to elicit responses incompatible with anxiety.

It should be noted that the two analyses are not as far apart as they at first seem. It is more the case that each emphasizes a different aspect from the other. Lorenz is concerned to show that on the first exposure the animal is at a maturational stage at which certain "innate perceptory patterns" are functionally capable of eliciting behaviour with respect to certain stimulus objects in the environment, much as "inductive determination" designates the process by which, at a very specific (early) stage in embryonic development, "transplanted cells owing to influences emanating from their new environment, are induced to develop in a way fitting to it, and not in the way they would have developed in their original position." (Lorenz, op. cit.)

*Moltz's brackets.
The stimulus object in the environment, which elicits the behaviour, is thought of as having certain properties which match those of the innate perceptory patterns, but also the external stimulus has other properties not "given" in the innate perceptory pattern, and the behaviour which is elicited upon exposure to the external stimulus is the result of two processes: in the first place the behaviour is "triggered-off" by the correspondence between certain properties of the stimulus object and those of the innate perceptory pattern; and secondly, the behaviour is conditioned to whatever other characteristics the external stimulus object may have but which are not "given" in the innate perceptory pattern. This latter process of conditioning has not featured in discussions by psychologists of Lorenz's views on imprinting to anything like the extent to which the innate perceptory patterns have. The reason for this is not hard to find. The conditioning process may be said to be akin to processes of the same name postulated by behavioural psychologists, whereas to many psychologists the postulate of an innate perceptory pattern as an explanation of the mechanism of a causal relationship is anathema. It smacks of mysticism and appears both gratuitous and useless to a behaviourist. It seems to mean that, in some way, the animal is born into the world having within it some kind of preview of what it will meet in the world, as well as an automatic connection between this innate preview and its motor organs, whereby it automatically produces a fully-integrated,
adaptive response pattern on first coming into contact with the particular object. While such postulates may, in a literary sense, account for the observed behaviour, it is felt that they do not do so in a functional sense. The sort of approach which is taken to be more realistic depends upon a developmental analysis of the changing structure, constant structure, changing physiology, constant physiology, changing environment and constant environment of the animal, as well as upon observations on the interrelations and interaction within these several aspects of the organism, and between these and observed behaviour (i.e., the constant and the changing functions of the organism in a given past and present setting). This sort of approach has been mentioned in discussing Kuo's position, and it will be referred to again with regard to Lehrman's criticisms of instinct theories.

Moltz, however, despite his main argument that imprinting can be adequately accounted for in terms of two different types of learning process, does have to introduce apparently inborn, species-specific properties of the maturational processes which he infers from his observations of the animal's behaviour. The difference between these and Lorenz's postulate of innate perceptory patterns does not rest entirely upon the different implications of the two sets of postulates, but also upon the terms in which they are couched. Moltz suggests that anxiety towards strange objects is not present in the animal--
to the extent that its overt expressions can be observed, at least—during its first exposure to the imprinting apparatus at a few hours of age, whereas, he says, it is present, and its overt manifestations are observable, during the second exposure a day later. In other words, the referrent of the term 'anxiety' develops at a fairly specific period in ontogeny, that it is not present before this period, and that it diminishes afterwards. Not only that, but the stage at which it appears varies with different species, (see p. 296, Moltz agreeing with this interpretation made by Hinde, Thorpe, and Vince, 1956). It is a matter of concern here whether the label 'anxiety' has become such an every-day part of psychology—whereas such terms as 'innate perceptory pattern', 'innate releasing mechanism', or more recently, 'releasing mechanism', and 'specific action potential', which have become common-place in Ethology, but have not in Psychology—that the former term is accepted while the latter ones are rejected largely because the former is not subjected to continuous critical appraisal, while the latter are. It is felt that the former, as a linguistic label designating an inference, or a hypothetical construct, from observed behaviour, have many of the same implications as the latter terms, which are likewise inferences, or hypothetical constructs from observed behaviour. But whereas the latter terms are generally unacceptable because of these implications, the former terms are accepted, and these same implications ignored.
With this in mind the two theories may be pictured somewhat as follows: both include an ethereal postulate together with a learning process (that this too is poorly defined was mentioned earlier). In Moltz's case there are two learning processes. For Lorenz the learning process appears to operate independently of, although simultaneously with, the postulated 'innate perceptory pattern', and is not necessary to account for the following per se, (since this is triggered-off by the correspondence between certain characteristics of the external stimulus and those of the innate perceptory pattern). For Moltz the postulated 'anxiety' features as part of both learning processes. On the first exposure the low anxiety is conditioned to the target-object,* and on the second exposure, since the target-object is now associated with low-anxiety, whereas the rest of the imprinting environment evokes high anxiety, following the moving target-object serves to reduce the animal's anxiety. One further point with regard to the actual similarity between the two positions, despite their linguistic divergence: Lorenz (1955) now considers that his earlier distinction between imprinting and conditioning should not be stressed; he suggests that the two should be thought of as continuous rather than as discrete processes.

*The term 'target-object' is used simply as a convenient shorthand means of describing the object followed, or to be followed.
It is appropriate to turn now to Lehrman's (1953) critical discussion of instinct theories, which focusses upon the two very similar theories of Lorenz and Tinbergen (e.g., Tinbergen, 1942). The most relevant problem raised and discussed is that of the "innateness" of behaviour. Lehrman first examines the way in which Lorenz and Tinbergen use the terms innate and inherited, and summarizes this as follows:

It is thus apparent that Lorenz and Tinbergen, by 'innate' behaviour, mean behaviour which is hereditarily determined, which is part of the original constitution of the animal, which arises quite independently of the animal's experience and environment, and which is distinct from acquired or learned behaviour.

It is also apparent, explicitly or implicitly, that Lorenz and Tinbergen regard as the major criteria of innateness that: (1) the behaviour be stereotyped and constant in form; (2) it be characteristic of the species; (3) it appear in animals which have been raised in isolation from others; and (4) it develop fully-formed in animals which have been prevented from practicing it.

He then goes on to say:

Undoubtedly, there are behaviour patterns which meet these criteria. Even so, this does not necessarily imply that Lorenz's INTERPRETATION (Lehrman's emphasis, P.J.D.) of these behaviour patterns as 'innate' offers genuine aid to a scientific understanding of their origin and of the mechanisms underlying them.
After examining several behaviour patterns which do in fact meet these criteria, and which have been analyzed in great detail at successive embryonic stages, with particular regard to the organization of body components, the distribution of forces (especially those emanating from the rhythmic contractions of the heart), and the resultant stimulation and passive movement of the body components (see Kuo, 1932, concerning the development of pecking movements in chickens), Lehrman concludes:

The behaviour patterns concerned are not unitary, autonomously developing things, but rather they emerge ontogenetically in complex ways FROM THE PREVIOUSLY DEVELOPED ORGANIZATION OF THE ORGANISM IN A GIVEN SETTING. (Present writer's emphasis).

One of the conditions which is normally claimed as being essential to the proof that an observed behaviour pattern is innate is that the animal exhibiting it must have been reared continuously in isolation from other members of his species. That this proves nothing of the kind is aptly brought out in the following passage from the same source:

It must be realized that an animal raised in isolation from fellow-members of his species IS NOT NECESSARILY ISOLATED FROM THE EFFECT OF PROCESSES AND EVENTS WHICH CONTRIBUTE TO THE DEVELOPMENT OF ANY PARTICULAR BEHAVIOUR PATTERN. The important question is not 'Is the animal isolated?' but 'FROM WHAT is the animal isolated?' (Emphasis is Lehrman's).
To bring out the flaw by means of a more vivid example, suppose the question were asked of a chemist, "Is the behaviour of this element innate?" How would he set about answering it? The fact that the question would not normally be phrased in this way does not deny, of course, the validity of its meaning. Suppose the chemist kept a single unit of the element locked in a box away from all other units of the same element. Suppose then that he later unlocked it, and introduced it into a given experimental environment. The result was that it underwent a certain change, and that whenever he repeated this procedure with other units of this element, they all underwent the same change. Would he then conclude that the behaviour is innate? Would he not rather begin a more intensive study of the atomic organization of the element, both before it was locked in the box and after it was removed from it (and while it was in the box, if he could conveniently do so without changing, by his examination, the very thing he was examining)? Would he not likewise investigate the physical and chemical properties of the environment at each stage? If he did all this, it is doubtful whether his final conclusion would be that the behaviour is innate, but instead, he would describe the interaction within the element of its various properties, and between these and the properties of the environment over the temporal sequence involved (including the time when the element was placed in the experimental environment and
underwent the observed change), and out of this he would have arrived at and causally explained the behaviour in question.

With reference to this type of developmental analysis of behaviour which has been subsumed under the headings innate or instinctive, Carmichael (1927), and Lashley (1938) also conclude in its favour, although the former finds some objection to Kuo's presentation. Beach (1955) contends:

> When these methods have been applied to the various types of behaviour which today are called "instinctive", the concept of instinct will disappear, to be replaced by scientifically valid and useful explanations.

Whatever changes instinct theorists have made in their theories in the face of this sort of criticism, they have rightly insisted that the type of behaviour under consideration, whether or not it should be called innate or instinctive, does pose a unique challenge to all those concerned with the explanation of the causation of behaviour. It can regularly be shown that it occurs within a given species, in stereotyped form, that learning and training in the conventional sense have played no part in its development, and that it is not dependent for its initial occurrence upon conventional reinforcement. In meeting this challenge it is clear that the most important factors to be considered are those numbered by Hebb (1958) as factors 1, 2, and 4 in his list (p. 121)—the genetic factor, deriving from the physiological properties of the fertilized
ovum; the prenatal chemical factor, deriving from nutritive or toxic influences in the uterine environment; and the constant sensory factor, deriving from the pre-and postnatal experience normally inevitable for all members of the species. Factor 3, the postnatal chemical factor is presumably of less importance if the behaviour in question occurs immediately at birth, but since most observations are made some hours, or even some minutes, after birth, the relevance of this factor should not be minimized. A case in point is that of imprinting itself—to the writer's knowledge, there has been no mention of a certain factor of this class which might well be expected to contribute to the facilitation of imprinting (in both a literary, and a psychological sense) namely that of heat loss—heat production. The relation between heat loss and movement is well established in physiology, and since the chick, on the first exposure, is only a few hours old, is probably still damp to some degree, and is removed from the heat of its living quarters and placed in a somewhat colder area without a direct external heat source, there is every reason to expect that it will show a significant amount of movement. This does not mean to imply, of course, that it will thereby run after the target object, but it does imply that once it does so, the extra heat production within the animal will contribute to the continuance and strengthening of this response, in much the same way, but in the opposite direction, that Moltz suggests anxiety reduction reinforces the response. Whereas anxiety is a somewhat vacuous
concept, heat changes do at least lend themselves to objective measurement and manipulation, and, being something other than the behaviour in question, (although a suggested causal factor in that behaviour), avoid the danger of circular argument. This is one thing which came out of the observations of the behaviour of the animals both within the imprinting situation, and outside it, and should not appear here, perhaps, but it does illustrate the importance of factor 3. [N.B. Although temperature is a physical factor, rather than strictly chemical, it clearly belongs under this heading; see Hebb's (1958) discussion of the way in which the factors are grouped, pp. 120-126.] Although birth is commonly referred to, in psychoanalytic literature, as a traumatic event, or even as the most traumatic event—leading to feelings of rejection and so forth—it cannot be included under Factor 6, even though it may normally involve the destruction of cells, since it is certainly not one of an 'abnormal' class of events to which an animal might conceivably never be exposed (Hebb, op. cit.). The changes constituting and resulting from birth will be amongst the most relevant to the causation of immediate postnatal behaviour, an obvious point, but one which has been largely ignored by at least the earlier instinct theorists.

This then is the background to, and setting of, the present study of early development in the chick. It is an important factor underlying the adoption of the present
procedure. This procedure demands that the behaviour of the chick, outside the experimental imprinting situation, but in various kinds of more-or-less normal situation, be examined with a view to establishing a baseline against which to compare the chick's behaviour in the more experimental imprinting situation. Above all, it emphasizes the close continuity between observation and experimentation, and it reduces the probability that interpretations and theories of imprinting behaviour will be artificial.

B. THE LITERATURE RELEVANT TO IMPRINTING

Most investigations of imprinting took place in the 1950's, the most important exceptions being Spalding's observations in 1873, Heinroth's work, reported in 1910, and Lorenz's and Bruckner's studies in the 1930's. Beach and Jaynes, in 1954, discussed the effects of early experience upon the behaviour of animals, and Moltz, in 1960, reviewed the literature on imprinting in connection with the theory he was proposing to account for the effects of the experimental procedure involved. Hinde (1961) provides an excellent discussion of parent-offspring relations, which focusses upon imprinting.

Due to Haldane's interest in Spalding's work, it was republished in 1954 and thereby was brought directly to the attention of contemporary behavioural scientists. Spalding pointed out that newly-hatched chickens tend to press against
many objects, interpreting this as due to their need for warmth. This was confirmed by Collias (1952) who reported that contact with a human hand, fifteen minutes after hatching, diminished the animal's distress calls. Collias also found that there were fewer such calls when the birds were hatched at higher, rather than lower, temperatures, and that they were similarly reduced in the presence of the clucking of a hen. He noted that the introduction of a moving object at this time (15 minutes after hatching) did NOT lead to reduced distress calling, although it did have this result an hour later.

Spalding reported that chicks reared in a flannel bag, with hoods and ear-plugs, on first having these removed and being placed a few feet from a hen, ran to the hen. This does not occur after the chicks are eight hours old, if they have not seen the hen before then. (Wood-Gush (1955) cites Bruckner, 1933, as confirming this.)

According to Spalding, chicks, blindfolded from hatching to between one and three days thereafter, instinctively preened themselves and scratched the ground when their vision was freed, and showed fear or suspicion of stinging insects at this time, but would attempt to catch flies. They would peck at many small objects, including their own excreta. This latter point is confirmed in the observations to be reported, but the present writer found that chicks, not blindfolded from
birth, showed a startle response, (to be described in detail in Chapter III), to flies and suchlike which happened to fly near them, and continued to watch their movements, but made no attempt to catch them. It is possible that Spalding's chicks on this occasion were older than those observed by the present writer, apart from the difference in their visual experience. Both Spalding's and the present writer's chicks did not drink water without first having pecked at bubbles in the water visible through the glass container, and through the water itself. With regard to fear, Spalding notes that a chick, 12 days old, gave a danger call when a sparrow-hawk flew overhead, and a week-old brood took cover in the presence of the same stimulus. (See Melzack et al., 1959, for a first-rate investigation of this matter.) Bruckner (op. cit.) found that chicks of less than seven days old show fear at a loud noise and at loss of equilibrium. Collias (op. cit.) reports that the approach of a large object would elicit distress calls in week-old birds, but that this reduced such calls when the animals were one hour old.

Chicks show attachment to humans or other objects, which are moving, when they are just able to walk. If blindfolded from birth until the encounter with humans, the chicks show no fear of them if the initial encounter is when the chicks are between one and three days old; if they are four days old, they show terror at such an encounter. (Spalding, op. cit.)
Bruckner (op. cit.) reported that chicks brooded by a hen showed fear earlier than those artificially brooded. Both Bruckner and Collias state that chicks recognize their own hen by auditory and visual means, but hens generally do not recognize their own chicks individually. The calls of the chick are more effective than its movements in eliciting aid from the hen.

With regard to the much discussed question of whether the chick's pecking is due to maturation or learning, it is interesting to note that Spalding's observations were so acute that he arrived at essentially the same conclusion as did Cruze (1935) as a result of the latter's systematic experimentation: Spalding saw that chicks blindfolded from hatching, with the blindfold removed at between one and three days of age, pecked fairly accurately within fifteen minutes, but that the rest of the feeding behaviour (i.e., holding the object in the mouth while raising the bill, and swallowing) was less efficient. Cruze likewise found that accuracy in initial pecking increases with the age of the chick at the first trial, (although practice quickly increases this accuracy further). Accuracy of the total response, however, depends largely upon the amount of practice, although older chicks require less practice in the total response to achieve a given degree of accuracy than do younger ones. Swallowing, when material is in the mouth, appears to be reflexive, and Kuo (1932) indicates
that it occurs before hatching. Some of these forms of behaviour may not appear to be related to imprinting. One of the arguments to be presented in Chapters IV and V, however, is that the form of behaviour which typically characterizes this imprinting, namely following, is far from being the only, or even the typical form of behaviour shown in the presence of the target object. Such other behaviour always includes watching, often includes pecking, both at the object and at the ground while in the vicinity of, or following the object, and may include running to the walls. If this is so, then it is appropriate to consider what has been reported concerning the development of these items of behaviour, and concerning the range of objects to which they have been shown, as well as the conditions in the respective experiments.

Lorenz's work, (1937), has been mentioned already, but it is well to extract from his writings the data on which his theory is based. This is particularly useful since the data, their interpretation, and their discussion are often closely interwoven in his presentation. To do this, the general and non-specific statements which imply but do not describe experiments and their resultant data will be ignored, as will the hypothetical or conditional sentences which suggest that certain facts have been, or could be established, but which do not provide specific evidence to that end. While this may be an injustice to the way in which Lorenz presents his work, it is
nevertheless essential if the evidence is to be critically appraised.

He says: (pp. 247-252):

Heinroth failed to breed hand-reared Great Horned Owls, Ravens, and other birds, for no other reason than that these tame individuals responded sexually to their keepers instead of to each other.

Portielje, of the Amsterdam Zoological Gardens, raised a male of the South American Bittern (Tigrisoma) who, when mature, courted human beings. When a female was procured, he first refused to have anything to do with her but accepted her later when left alone with her for a considerable time. The birds then successfully reared a number of broods, but even then Portielje had to refrain from visiting the birds too often, because the male would, on the appearance of the former foster-father, instantly rush at the female, drive her roughly away from the nest and, turning to his keeper, perform the ceremony of nest-relief, inviting Portielje to step into the nest and incubate!

I once had a pair of Greylag Geese hatch a Muscovy Duck's eggs. The parent-child relations in this artificial family dissolved sooner than is normal for any of the two species, owing to some hitches in mutual understanding which occurred because...(theoretical explanation).... From the seventh week of their life, however, the young Muscovies had nothing more to do with their former foster-parents, nor with any other Greylag Geese, but behaved socially toward one another, as well as toward other members of their species as a perfectly normal Muscovy Duck should do. Ten months later the one male bird among these young Muscovies began to display sexual reactions and, to our surprise, pursued Greylag Geese instead of Muscovy Ducks, striving to copulate with them, but he made no distinction between male and female geese.
In 1936, I kept a young Greylag isolated from its kind for over a week, so that I could be sure that its following-reaction was securely attached to human beings. I then transferred this young goose to the care of a Turkey hen, whom it soon learned to use as a brooding-Kumpan for warmth instead of the electric apparatus it had hitherto favoured. The gosling then followed the Turkey hen, provided that I was not in sight, and kept this up for a fortnight; but even during that time I had only to walk near the two birds, to cause the gosling to abandon the hen and follow me. I did this but three times to avoid conditioning the gosling to myself as a leader. When, after two weeks, the gosling began to become more independent of the warming function provided by the Turkey hen, it left her and hung around our front door, waiting for a human being to emerge and trying to follow it when it did so. Now this gosling, excepting the few necessary trial runs, each of which did not last more than about a minute, had never actually consummated its following-reaction with a human for its object. On the other hand, for more than two weeks, it had been in constant contact with the Turkey hen; yet its following-reaction did not become conditioned to the Turkey in preference to the human. I would even suspect that its instinctive following-reaction was never really released by the Turkey at all, and that its following the hen was predominantly a purposive act, directed to the necessity of getting a warm-up from time to time. It never ran directly after the Turkey hen in the intensive way in which it would follow me and in which Greylag goslings follow their normal parents, but just kept near her in a most casual and deliberate sort of way, quite different from the normal reaction.

I began experimenting by having Mallards hatched by a Muscovy Duck, with the result that they ran away from her as soon as they could, while she continued incubating on the empty shells. Foster-mother and young failed completely to respond to each other. Heinroth had exactly the same experience when he tried to let young Wood Ducks hatch under a Mallard. I
decided to try experimenting on the call-note which is happily well within the powers of the human voice to imitate. I took seven young Mallards and while they were drying under the electric heater I quacked to them my imitation of the mother Mallard's call. As soon as they were able to walk the ducklings followed me quite as closely and with quite the same reactional intensity that they would have displayed toward their real mother. I regard it as a confirmation of my preconceived opinion about the relevance of the call note, that I could not cease from quacking for any considerable period without promptly eliciting the 'lost-peeping' note in the ducklings, the response given by all young anatides on having lost their mother. It was only very much later, probably after much conditioning to other characters inherent to my person, that they regarded me as their mother-companion even when I was silent.

The last piece of relatively detailed reporting in this article concerns the varying degrees of specificity of the postulated innate perceptory patterns occurring in different species (pp. 253-254):

Another example of a species with wide and little specific innate perceptory patterns is the Shell Parakeet (Melopsittacus undulatus). I raised in isolation a young bird of this species, which was taken out of the next of its parents at the age of about one week. It was reared in such a way as to expose it to as little stimulation from the keeper's side as possible. When fledged, it was confined to a cage in which a celluloid ball was so attached that it would swing to and fro for a considerable time if accidentally touched by the bird. My intention to transfer the sexual and social reactions of this bird to the very simple contrivance mentioned, succeeded beyond all expectations. Very soon the bird kept continually near the celluloid ball, edged close up to it before settling down to rest and began performing the actions of social preening with the ball for an object. Notwithstanding the fact that the celluloid ball had no feathers, the bird minutely went through all the movements of preening the short plumage of another bird's
head. One most interesting item in the behaviour of this bird was that evidently he was treating the celluloid ball as the head of a fellow-member of the species. All actions which he performed in connection with it were such as are normally directed toward the head of another parakeet. If the ball was attached to the bars of the cage in such a manner that the bird was at liberty to take any position relative to it by holding onto the bars, he would always do so at such a level that his own head would be at exactly the same height as the celluloid ball. When I attached it closely to a horizontal perch, so that it was much lower than the head of the sitting bird, he would be at a loss what to do with his companion and looked 'embarrassed'. Throwing the ball loosely on the floor of the cage elicited the same response as the death of the only cage-mate does in Shell Parakeets, namely, the bird fell absolutely silent and sat still in the 'fright-attitude' with feathers depressed close to the elongated body. The only instinctive reaction not normally addressed to the head of a fellow-member of the species that I could observe in this isolated bird, was the following: males in courting a female excitedly run up and down a perch in a quick sideways movement and finally sidling up to her, they grip in a playful way at her lower back or at the base of her tail, using one foot and standing on the other. When my parakeet grew to mature age and began more seriously to court the celluloid ball, he would execute exactly the same movements, but, as he was aiming them in such a way that the ball represented the female's head, his thrust-out claw would grip only vacancy below the celluloid sphere dangling from the ceiling of his cage.

From these quotations it will readily be seen to what extent Lorenz interprets and even suggests theoretical explanations for the behaviour in the midst of describing it. Again, in almost no instance is there given sufficiently precise detail of the developmental history of the animals in the
observation or experiment such that it can be adequately judged whether the evidence justifies the interpretations made. Such a situation by no means implies that the interpretations are either incorrect or correct; this is precisely what cannot be decided without an examination of the missing details. Bear in mind that these quotations are those which represent the most specific portions of the paper, and much of the rest of it contains further suggestive but not demonstrative data, of an even more general nature. In defence of Lorenz's presentation it can be said that he was at the time attempting to provide a theoretical framework for the behaviour evidenced in imprinting situations rather than simply to put on record the experiments and observations he had performed. However this may be, the theory he presents is very definitely an 'instinct' theory and since it is open to the criticisms (e.g., Lehrman's) already referred to, more specific data are needed before an adequate causal explanation of the behaviour in question can be reached. For a statement of the four most significant characteristics of imprinting, see the earlier presentation of Lorenz's viewpoint (p. 10 above), to which matters further attention will be given in Chapter IV.

Fabricius (1950) in reporting a number of his experiments confirmed much of the earlier data, and added to it further: Stuffed dummies of adult female ducks of the same species as the ducklings, which remained motionless and silent produced no reaction in the young. (He does not make clear
whether he means no following-reaction, or no reaction whatsoever; since he speaks almost exclusively of the following-reaction in his paper, this could refer to either of these two possibilities. Later in this thesis it will be suggested that many changes in behaviour other than following warrant inclusion under this heading.) When these dummies were drawn forward along the water, they elicited either escape behaviour or the ducklings paid no attention to them. The eleven ducklings used here were all of the same species, and were newly-hatched. In another part of the investigation, seventeen newly-hatched ducklings were presented with somewhat older ducklings of species other than their own; ten of the seventeen crept to the other species and followed, in spite of being harassed and nipped violently. Some of the observations to be reported here confirm this; it is amazing to the observer how much punishment the newly-hatched birds will take, and still approach the older bird. Fabricius reports that newly-hatched ducklings paid no attention to a human sitting motionless and quiet, but that they ran to a moving hand and arm, and followed if the human walked away. He concludes that shape is not important in eliciting following, but "the most effective optical stimulus must be any quality of movement, characteristic of living vertebrates, but not occurring in a swimming model drawn forwards along the surface of the water." There is much evidence, however, that the motion need not be as specific as this,
indeed, objects on pulleys, moving hides (with the legs of the person inside hidden), and so forth, have all been shown to elicit following (see, for example, Hinde, Thorpe, and Vince, 1956). Ramsay and Hess (1954) report that ducklings respond more readily to a model of the male of the species than to a box, and Jaynes (1956) found that chicks prefer a red cylinder to a green cube. It is not clear whether form or colour is the more important factor, but both these findings are in contradiction to the above conclusion. It is worth noting that Hess and Gogel (1954) found that chicks prefer light, desaturated colours (in a non-imprinting situation, at least). The question requires systematic investigation before any conclusion can be reached. That even the direction of the lighting may influence the matter is suggested by Hess' (1950) work. Julian Huxley sums up the present state of knowledge by his comment (in the recorded discussion of Hess' 1956-57 paper): "...this, I think, is one of the strange things about imprinting—that the specificity of the sign stimulus, so striking in many animal reactions, is largely, although not entirely, abolished." Although the quiet, motionless human evoked no approach behaviour from the ducklings, they did show this if the human called "Kom, Kom, Kom," etc. Further, this auditory stimulus, when the ducklings were placed in an opaque-walled box without a specific visual stimulus, lead to a change in the vocalization of the birds from distress calls to pleasure notes; the birds also crept in the direction of the sound-source. The "swimming" model mentioned above was
approached by the ducklings if it was accompanied by the sounds, whereas they paid no attention to it when the sound was absent. Fabricius notes that it was sometimes necessary to repeat these sounds for some seconds before the birds would follow, "showing that the stimulus was successively accumulated until the level of reaction was reached." Although this may be thought of as a plausible explanation of the delay in these cases, one wonders whether the ducklings did not sometimes require a second or two to locate the source of the sound before they could move in that direction. Also, why should some birds need the stimulus to be "successively accumulated" while others, apparently, followed at once? Finally it should be noted that such an interpretation would be difficult to test—especially in view of the fact that it operates in some birds but not in others; what would be the nature of the prediction in a given instance—that it would operate, or that it would not? Neither result would refute the suggested explanation.

In the cases where the ducklings were following the moving human, following "was always better" when he called as well as moved. This is interpreted as an example of 'heterogeneous stimulus summation', following Tinbergen (1948).

With regard to the sensitive period during which imprinting is possible, Fabricius found that, with birds isolated in the incubators for various periods after hatching, the greatest reaction, in the case of tufted ducks, occurred
when they were less than 12 hours old, decreasing rapidly with increased age (of first exposure). When the first exposure was at 24 hours or older, no following was observed. With mallards, however, following could be elicited when the exposure was delayed until up to 72 hours, with the same inverse relationship holding between age of initial exposure and probability of following. Other experimenters, using a number of different species, found differences in the critical period ranging from up to or about 8 hours of age [in the case of Peking ducks, (Moltz, 1960, citing Moltz and Rosenblum, unpublished), and in the case of coots, (Alley and Boyd, 1950)], to six days of age [in chicks (Jaynes, 1957), and in coots (Hinde, Thorpe, and Vince, 1956)]. With these older ages, however, it is more the case that this appears to be the outside limit of the period during which following can be elicited, rather than the optimal period, which, in most species investigated, seems to be during the first day, especially at around 16 hours of age (Ramsay and Hess, 1954; Moltz, 1960, citing Moltz and Rosenblum, unpublished; Jaynes, 1957). It appears to be the case that, both before and after an approximate critical period for a given species, the percentage of birds following, or the ease with which the following is evoked, or the percentage of correct choices in a subsequent test involving the familiar model and an unfamiliar female decoy (Ramsay and Hess, 1954), declines. Fabricius (op. cit.) notes that the effect of a visual stimulus decreases more rapidly than that of an
auditory one, and the two together elicit better following in older ducks than a visual stimulus alone--BUT an auditory one alone released the reaction in still older ducklings. This last finding, which appears to contradict any notions of "heterogeneous stimulus summation," is explained as follows: a visual stimulus alone will sometimes elicit escape reactions, instead of following, if the birds are at least six hours old, whereas the particular auditory stimulus used, ("Kom, Kom," etc.), would never give rise to escape reactions. Although Fabricius does not go into this further, he appears to mean that the auditory stimulus could be given an arbitrary rating for effectiveness as +2, and the visual stimulus would be rated ambivalently for older ducklings as +1 and -1. Suppose then that, for whatever reason, the visual stimulus, on a given occasion, were acting in its negative capacity, and both stimuli were presented together to a duckling over 6 hours of age; this would result in a net effectiveness of +1 (i.e., +2-1). Now, although, if the visual stimulus were functioning positively on this occasion, the effectiveness would be +3, which is greater than the effectiveness of the auditory stimulus alone ( = +2 ), and which is presumably the case with "heterogeneous stimulus summation," as the age of the duckling at the time of the exposure is allowed to increase, the probability that the visual stimulus will elicit the negative (escape) reaction quickly increases, with the result that in the majority of cases, the two stimuli together will have an effectiveness of
+1 at best (since the visual stimulus by now is becoming more negative than before), whereas the auditory stimulus remains with an effectiveness of +2. These ratings are purely hypothetical, of course, but this analysis seems to be the sort of thing implied by Fabricius. He states that, in some cases, where the visual stimulus was presented alone, and had given rise to escape behaviour, if the experimenter began calling "Kom", the bird would stop, and might, if the auditory stimulus were continued, turn back and follow. This would fit the suggested analysis.

With regard to the irreversibility of the response, Fabricius reports that ducklings who were imprinted to a human would not follow other ducks, but he notes that, in some cases, "a kind of incomplete imprinting occurred." The young ducks would be following the human, "but every sudden or rapid movement released escape reactions in them." This occurred especially with those birds who had remained isolated in the incubator for a long time. As already noted, his criterion of imprinting seems to involve only following behaviour. This will be seriously questioned in a later chapter, in discussing the observations to be reported, but it may be noted that the phrase "a kind of incomplete imprinting" loses much of its meaning if the behaviour referred to—other than the following—is part of a normally occurring but less conspicuous, and therefore apparently less relevant, pattern. To anticipate for
a moment, the present writer found that in the imprinting situation the chicks showed an immense variety of behaviour, most of which was NOT a constituent part of the following. Indeed, the most characteristic "single item" of behaviour, insofar as this phrase has meaning, was watching the target object. Even the following reaction itself varied tremendously in form--most chicks preceded the object rather than followed it, some stayed close to it most of the time, while others would let it get several feet ahead of them and then dash half the length of the pen to it, while others spent as much time walking or running along the walls of the pen as they did in the immediate vicinity of the target object, although they were clearly orienting their overall behaviour towards the object. This poses a problem for the definition of imprinting as a phenomenon--both "incomplete" and complete. Jaynes (1956) also stresses that there is more to the behaviour than simply following, although he bases most of his discussion on a criterion which involves only following. This depends, of course, on the definition of imprinting, and will be returned to later. In his theoretical discussion, Fabricius closely follows Lorenz's interpretation, in terms of innate perceptory patterns and innate releasing mechanisms (I.R.M.).

Before leaving the discussion of the critical period, it is well to note that such a concept is by no means unique to imprinting as a phenomenon or as a process. For example, Scott
and Marston (1950), and Williams and Scott (1954) discussed critical periods for the development of social behaviour in dogs and mice respectively, while much the same sort of concept features in psychoanalytic theory. Scott and Marston suggest that the critical period hypothesis may reconcile many of the conflicting results of experiments with infants, finding, as they do, that the effects of early experiences, especially traumatic ones, are far more important during critical periods than at other times. With regard to dogs, they conclude that the period from about 3 1/2 weeks of age, when the puppy leaves the nest and meets other individuals, until eight to ten weeks, the time of weaning, is the most important one in the development of social behaviour.

The paper by Alley and Boyd (1950) is important mainly in attempting to relate imprinting and other forms of early maturation and learning to species and individual recognition. Working with coots, they concluded that the reactions of the young were controlled by 'releasers', in particular releasers of following, and alarm, reactions. In the period up to about 8 hours of age, young coots will follow humans, accept food from them, and respond to calls made by them. By the second day, however, this behaviour disappears, except in the case of hand-reared young. At first the young will follow and beg from any adult coot, but by about eight to eleven days they have learned to avoid adult coots in an attitude of attack. This is
very much to the advantage of the young, since adult coots will not tolerate them unless the adults happen to have young themselves which are both similar to the intruders and less than two weeks old. The young appear to recognize the adults individually (i.e., over and above species recognition) by about three weeks. The basis of such recognition is probably mainly if not entirely visual (including the recognition of behavioural characteristics), since it is doubtful whether birds have any olfactory sensations, as olfactory stimuli have not been effective as conditioned stimuli in conditioning experiments (Walter, 1943, cited by Thorpe, 1951). In this paper Thorpe, discussing the learning abilities of birds, refers to Imprinting as an "innate disposition to learn". He follows Lorenz in maintaining that patterned stimuli in the environment serve as the key to unlock instinctive behaviour, and relates imprinting to the acquisition of territory and song.

Ramsay (1951) is concerned to establish the sensory factors that are involved in eliciting the following reaction and in familial recognition in domestic birds. He finds that such birds respond to vocal cues, (marked) differences in size, form, and extreme differences in colours (shades and tints being ineffective). These factors, he suggests, vary according to the species under consideration. It is important to note that he discounts behavioural traits, although many such traits, being stereotyped and species-specific, would be
expected to function in species recognition. This seems to be part of what Lorenz (1937) meant when he said, in one of the passages quoted earlier, "The parent-child relations in this artificial family (adult Greylags and young Muscovies, P. J. D.) dissolved sooner than is normal for any of the two species, owing to some hitches in mutual understanding which occurred because the key and lock of the releasers and innate perceptory patterns of both species did not fit." With regard to the relative range between species, of objects which will elicit a following reaction, Ramsay found that incubator-hatched chicks and Canada Goose goslings would follow a small green box containing an alarm clock, the goslings and Muscovy ducklings responded to a football, but Mallards responded to neither of these. One wonders whether the greater specificity required in the objects which Mallards will follow is linked with the relatively long period in which their following can be elicited (Fabricius, 1950). Guhl and Ortman (1953), investigating the reactions within groups of chickens to changes in the appearance of one of the members of the group, found that individual birds react to alterations in another bird's plumage, to intense colour changes in the other bird, and to disguised features of the head and neck rather than of the rest of the body. The main criterion was whether the peck-order was disrupted when the altered bird was returned to the group. These findings are similar to those of Ramsay (1951), cited earlier, but, in contradiction to Ramsay, Guhl and Ortman found
that deportment is an important factor in individual recognition. They conclude that some factors appear to be more significant than others, but that no single factor is the sole means of recognition, and they note that "Modification of features has to be abrupt and quite pronounced to cause a loss of recognition." Their experiments lack the control condition in which a chicken is removed, handled in the same way that the chicken being altered is handled, (except that no alteration is made to it), and returned to the same group. This may or may not be important, but it is worthy of mention that they report that a chicken (unaltered in plumage, etc.) shows a change of deportment when placed in a strange group of chickens. Since these investigators found that a change of deportment does influence recognition, a report on the behaviour of the control chicken, and on its reception by the others in its own group, might aid in determining the relevant factors in individual recognition.

Collias (1952) in discussing the development of social behaviour in birds, maintains (p. 155):

Social development is part of the development of behaviour in general, and as such may be traced back through physiological and chemical levels of organization to genetic factors. What genes determine in this indirect fashion is the tendency to respond to more or less specific social situations; and the interaction between different levels leads to social development.

This means that physiological changes (in the secretion of hormones, for example) interact with social situations as
variables in behaviour. He describes the development of behaviour by means of an embryological model (plasticity, induction, etc.), and social patterning by means of a model of neural activity. In line with this position, he states: "The basis for social reactions is largely developed by the embryo before hatching takes place." Trends in the socialization of the young bird after hatching are summarized as follows:

1. Relative inactivity (some "spontaneous" or endogenous activity).

2. Generalized social responses which become "strengthened, fixated, directed, and specified by social experience."

3. A period of increasing social INDEPENDENCE, leading to the break-up of the family unit.

4. Reintegration into new groups, for example, a grouping based on the establishment of a dominance hierarchy. Such groups are influenced by the balance of cooperative and competitive tendencies in the birds, and are facilitated by example and leadership. This precedes socialization, as parents within a new family group.

A paper by Nice (1953) records some of her experiences in imprinting twelve ducklings of five different species. She used the same technique as did Fabricius, namely moving her arm around near the ducklings, or walking away from them, calling in both cases, "Kom, Kom, Kom," etc. and her findings agree with those of Fabricius and Lorenz cited above. One conclusion is
that the earlier the exposure and the more heterogeneous the stimulation, the more readily is imprinting effected.

Since many references to specific types of call are found in the literature, a paper by Collias and Joos (1953) warrants consideration in this context. These investigators made spectrographic records of the sounds made by the domestic fowl, and related these to the concurrent behaviour of the bird. They classified the sounds as follows:

A. Sounds made by chicks include distress calls, pleasure notes, and fear trills.

B. Sounds made by broody hens, that serve to attract chicks, include clucking, food calls, and the roosting call.

C. Warning signals include the alarm call for aerial predators, the alarm call for ground predators, the alerting call of a broody hen, fear squawks of a hen held in the hand, threat sounds by cocks, and the crowing of a rooster.

They found that the distress calls of chicks are composed of descending frequencies only, while pleasure notes contain ascending frequencies predominantly. Sounds that attract chicks have the following common elements—repetitiveness or segmentation; brief duration of the component notes; the presence of relatively low frequencies. Warning notes, on the other hand, include such opposite features as long duration, little segmentation or repetitiveness, and absence of low frequencies.
Experimental tests with a variety of sounds verified these conclusions. Thus when an observer speaks of distress calls or pleasure notes, and so forth, he is probably on fairly safe ground; the classification just referred to, however, was based on an analysis of spectrographic records which may be quite different from the judgements made during the course of observation, without the aid of such a machine. The spectrograph provides a visual and permanent record, which can be analyzed at leisure afterwards, whereas it is often extremely difficult to judge whether the sounds heard include ascending frequencies, descending frequencies, segmentation and so forth. As will be noted later, the present investigator found that, while extreme differences in a chick's calls could be distinguished fairly easily, most of them seemed to be at different points of a continuum, or of several continua of intensity (especially), smoothness versus segmentation, and pitch.

In their review (1954), Beach and Jaynes point out that the supposed irreversibility of imprinting may not occur for some time after the initial exposure to the target object. For instance, they cite Lorenz's report that Jackdaws, taken from their nest at fourteen days of age, were found to be imprinted to their natural parents, but, after separation from adult jackdaws and continued association with humans from this time on, the birds' positive social responses could be shifted to humans. This shifting is possible apparently until about three weeks of age, after which time birds that have
been imprinted to adult birds can not be imprinted to humans, and vice-versa. It might well be expected that, since humans have fed and cared for the birds, in a number of cases, the subsequent attachment to humans might be due not so much to a reversal of imprinting as to "ordinary" reinforcement-learning. This seems to be the case with the wild gosling captured, when between one and two weeks old, by Steven (1955).

The gosling was placed in a cage on meadow-land, by humans. It was moved to fresh pasture each day, by humans. Water was provided, when required, by humans. They were humans, too, who let it out to graze and who stood near it while it was eating. It is not surprising that it soon lost its fear of the humans at the camp, and even the fact that it did not respond well to visitors to the camp requires no interpretation in terms of "re-imprinting." This, Steven claims, occurred on the sixth day after capture, "as a revolution in the bird's behaviour", although he does acknowledge that from day four the bird showed some positive responses towards humans, to whom it had originally shown fear responses. He suggests that imprinting and habituation are linked—when the fleeing tendency is lowered sufficiently, imprinting becomes possible. This would seem to imply that, so long as an experimenter could habituate a bird to fear-provoking moving objects, he could bring about transferences of imprinting indefinitely. In the case reported by Steven, however, any such interpretation seems unwarranted, since, firstly, reinforcement-learning must have...
played a major rôle, and, secondly, the behaviour of the bird, subsequent to these experiences, towards the original objects of its imprinting, its natural parents, was not observed. Since Lorenz's jackdaws would not shift their positive responses to humans if the birds were older than two weeks, however, reinforcement-learning cannot be the only factor operating in these cases. The experimental procedure which would allow a more decisive answer to be reached would involve allowing the newly-hatched bird to follow a human for some time, and then placing it in the presence of some non-human moving target-object for several trials. The original observation, on which Lorenz based his statement that imprinting is irreversible, was made under conditions such as these (see page above). During the week in which the young Greylag was isolated from its kind, and in contact with humans only, it was probably fed and cared for by humans (Lorenz is not explicit here), therefore the same procedure, but with stricter controls might well be worth adopting. In this case, suppose that—apart from any imprinting—the bird received food, water, warmth, and possibly some form of handling which might have been positively reinforcing, from the human(s) during the first week, and then, when placed with the Turkey hen, received warmth only from this bird (which, in any case, it needed less than before); would it then be surprising that the young Greylag "preferred" humans to a Turkey hen? It follows from this that imprinting has been shown to be neither reversible nor
irreversible. In fact, little, if anything can be said about imprinting in a case such as this. It will be recalled that Fabricius (1950) observed that, when ducklings were imprinted to humans, they would not follow other ducks, but, again, it is not certain that the birds received none of the conventional reinforcers from the humans. It is interesting to note that Nice (1953) found that the ducklings which were imprinted to her did not eat properly unless kept with other ducklings who were efficient eaters. This seems to be a case in which an attempt was made to avoid reinforcing the attachment to a human, but, unfortunately, no data on reversibility were reported. Nice goes so far as to state that, in these circumstances, unless the birds can either be kept with efficient eaters or fed by humans, they will die. This is, regretfully, the reverse of the control condition necessary.

Beach and Jaynes (op. cit.) also report that in some cases not all subjects, in an imprinting situation, follow, and some of a group, in which most of the birds react positively, are not imprinted (see especially Jaynes, 1956, 1957). This is one of the main findings of the present study, and it is surprising that scant mention of the matter has been made in the literature. These authors also refer to a number of studies of mammalian imprinting (Murie, 1944; Scott, 1945), but, again, the conditions (e.g., being bottle-fed by humans) point to an interpretation in terms of reinforcement-learning rather
than of imprinting. Gray (1958) takes the smiling of human infants to correspond to the following of newly-hatched birds. He finds evidence for a critical period lasting from six weeks (when the smile is first given to a nodding face) until six months (the onset of fear reactions), and cites the work of Bowlby (e.g., 1951, 1953), in particular, in support of his argument. Even if Bowlby's evidence were not, to a large extent, anecdotal and loosely controlled, his interpretation of the causal relationship between parental loss at a certain age and subsequent adolescent emotional and behavioural disturbance is open to serious question. In any case, it is notoriously certain that the almost continuous positive reinforcement extended to the human infant in the first six months of its life confounds any interpretation in terms of imprinting.

Ramsay and Hess (1954), in addition to the findings cited earlier in connection with the critical period and with form preferences, contribute some further data on the relation of fear to imprinting and on the nature of the relevant stimulus properties. Fourteen ducklings were exposed to the imprinting situation at between 21 and 24 hours of age. Of these fourteen, eleven showed strong fear responses. They point out that

It seems significant that the only ducklings that showed any appreciable imprinting in the 21-24 hour group were the same individuals that showed no alarm.
They found that, while noise was necessary to elicit approach to a stationary model, the ducklings showed no clear-cut preference between three types of noise-recorded duck quack, spoken simulated quack, and recorded human "gock". Motionless calling models were effective as target-objects, as evidenced on subsequent tests. They add a comparative finding that Cochin Bantams showed poorer imprinting than, but about the same critical period (13-16 hrs.) as the ducklings. The bantams preferred the recorded cluck of the mother hen to the human recorded "gock", which might account for their low imprinting scores, since the cluck of the mother was not used with the models presented to them as target-objects. Evidence apparently contradicting that of Fabricius, referred to earlier, on imprinting to sound alone, was that three ducklings, to whom a recorded "gock" sound was played from hatching until they were 24 hours old, showed no evidence of imprinting to that sound. Using somewhat different conditions, Fabricius found that ducklings stopped giving distress calls in response to his continued calling "Kom", (and other monosyllables), and that they crept towards the sound source. Some further evidence on this point will be presented in Chapter III.

Hinde (1955) uses imprinting as a descriptive example "of the ways in which behaviour, which has developed without the intervention of 'learning' processes, may be subsequently modified by them." In treating imprinting as "not fundamentally
different from other forms of learning," he suggests that its mode of action is to affect the stimuli which elicit the behaviour observed in a given situation. The reports (e.g., Lorenz 1935, 1937), that later-maturing behaviour may be directed towards the original target-object, are cited, but Hinde adds the important note that, in the case of subsequent responses directed towards man, in particular, this may well be due to the operation of other learning processes. The fact that following the moving object may be rewarding in itself is noted by Hinde—a suggestion which is certainly in accord with what is observed, but one which requires a serious revision of the traditional notions of reinforcement, as discussed earlier in this chapter. Verplanck (1955) introduces a slightly different interpretation of imprinting:

Imprinting is regarded as simple S-R learning occurring under somewhat special conditions. An initial weak tendency to follow moving objects of specifiable size is strengthened by repetition of the following behaviour. This following behaviour becomes restricted to a particular class of object by a later-appearing species--species-specific tendency to fear and to escape from objects of the same general class as that which initially excited following. Only the class of objects that the animal has had extensive practice in following retains the property of exciting following; the animal remains "tame" with respect to it. This sparing is a case of the transfer phenomenon called proactive inhibition in other contexts.

When adult behaviour appears, proactive inhibition should lead to interference (by persisting fear and flight components of
behaviour) with response to those objects that had NOT been followed prior to the appearance of the fear and flight behaviour in the animal's early days.

The parallel drawn, however, is not entirely unambiguous. Proactive inhibition normally arises in situations in which subjects are required to learn a list of items, and then to learn a second list. The ease with which they learn this second list is compared with that of a control group of subjects who learn only the second list. If their score is significantly lower than that of the control group, this is interpreted, ceteris paribus, as proactive inhibition—i.e., the process of learning the first list is said to upset the process of learning the second one. If the experimental group has a score, for the second list, which is significantly higher than the control group's score, this is called proactive facilitation. The corresponding experimental group in Verplanck's discussion is the group of birds who have been imprinted. The control group is made up of any other birds of the same species, reared in the same fashion, but having experienced no moving objects of the relevant class, prior to the development of the fear and escape tendencies. Each group at the adult stage would be confronted with the objects which the imprinted group (only) had followed prior to the appearance of fear and flight behaviour in their early days. Now, Verplanck maintains, "proactive inhibition should lead to interference (by persisting fear and flight components of
behaviour)" towards these objects now presented, in the case of the control group, while the experimental group should exhibit their usual (following) behaviour towards the objects. In other words the "score" of the experimental group would be "higher" than that of the control group; this is proactive facilitation not proactive inhibition. (A "higher score" means that they did not fear and flee from the objects presented.) A more serious difficulty lies in the fact that it is the control group which appears to be affected by proactive inhibition in this case--the group which did NOT undergo the initial learning; it is difficult to see how the parallel with proactive inhibition holds.

Fabricius notes, in 1955, that following, avoidance, or aggression might be shown by young Mallards towards simple moving models (mostly boxes and balloons) in a runway--a finding which agrees in all respects with those to be reported in Chapter III. He states that any model could elicit all these responses. The sensitive period was not sharply limited, but the highest proportion of followers was found among birds for whom the initial presentation was made when they were between twenty-five and fifty hours of age. This does not entirely agree with his earlier report (1951) on Mallards wherein he finds that the probability of obtaining the following was inversely related to the age at which the initial exposure occurred, but it does confirm that Mallards have a
longer sensitive period than do, for example, tufted ducks. He notes that older ducklings tended to show initial avoidance rather than following, and that:

Ducklings failing to follow the models also tended to avoid other ducklings on first meeting them. (See also Melzack et al., 1959, pp. 696-697)

The rigidity of the following, once established, was also investigated—the initial exposure was to a balloon and subsequent ones were to a box or to the balloon (in some cases the initial object was a box). The result was: "While several followed the strange model in addition to the familiar one, in all cases the response to the former was less intense." This is confirmed by Jaynes (1956) with respect to young chickens, and using red cylinders and green cubes. Fabricius also mentions that some model-followers developed a tendency to follow men after several weeks; this situation was discussed earlier.

Moltz (1960) points out that the supposed irreversibility of imprinting may mean either (or both) that once a certain type of object has been followed, objects dissimilar to it will not be followed (i.e., irreversible = no stimulus generalization possible), or that once an object has been followed, it will continue to be followed throughout the animal's life (i.e., irreversible = stable). Both Fabricius and Jaynes (op. cit.) were investigating stimulus generalization; the
question of the stability of the behaviour has been raised earlier in connection with Lorenz's early work, and it will be returned to in a moment. The abstract of Thorpe's paper (1955) reiterates the contention that imprinting is not a distinct form of learning, but that it has somewhat special characteristics, including that of being supra-individual learning.

Its function seems to be to build rapidly upon and so complete the adjustment of the innate releasing mechanisms of certain social behaviour patterns which are of crucial importance in the life history of the organism.

This is essentially the same as Lorenz's later position (1954). With reference to the question of irreversibility, Thorpe criticizes many studies on the grounds that the objects (especially if human) appear to have become "contaminated" with reinforcement (in Moltz's words), and that a clear-cut interpretation of the results becomes impossible.

Hess (1956-57) states that imprinting is the name given to the presumed fact that "early social contacts determine adult social behaviour." Although chiefly concerned with the effects of meprobamate on imprinting, he adds to our knowledge of the matter in a number of other respects. While most other experiments have been performed in an open-field situation (e.g., Lorenz, 1937), or using a straight runway and pulleys (e.g., Jaynes, 1956)—although Hinde, Thorpe and Vince (1956)
used a combination of these—Hess made use of a circular runway, five feet in diameter, twelve inches wide, and 12 1/2 feet in circumference at the centre. The target-objects were suspended from an elevated arm radiating from the centre of the apparatus, and were fitted internally with a loudspeaker and a heating element. The birds (Mallards) fell through a trap-door in the runway to be returned to their boxes. It is worth noting that this apparatus, but even more so the straight runway type, is set up in such a way that the bird is more free to move in a longitudinal direction, or around the circle in the latter case, than in a transverse direction (equivalent to moving towards or away from the centre of the circular apparatus). Its movement would be blocked sooner by the walls of the runway, if it moved transversely than if it moved along the apparatus. On a chance basis alone, therefore, one might expect more movement to occur along the runway, and, since this is also the direction in which the target-object moves, this effect should be taken into account in discussing the strength of the bird's following. The optimal type of apparatus would seem to be a walled circular area, with no equipment or walls inside the outer boundary. This would enable the bird to move equally freely in all directions within the circle. Pulleys, etc. would have to be supported from above, or the target-object moved by means of battery-supplied power, clockwork, or remote control.
Hess used an imprinting period which was "usually less than one hour"; this is considerably longer than the usual period, which varies from ten to thirty minutes. His test for imprinting involved a choice between the familiar and a strange model under four successive conditions of movement and/or sound by one or both of the models. The findings were that the optional period for imprinting is around the sixteenth hour after hatching; distance travelled, rather than length of exposure, is a crucial factor (in this part of the experiment, exposure time was held constant within each of three groups at 2, 10, and 30 minutes respectively); and that the drugs used on the birds had the following effects:

1) Meprobamate "reduces the fear or emotional behaviour (and) makes imprinting almost impossible. It does not, however, interfere with the effects of imprinting." By "almost impossible", Hess means during the normal critical period, as he points out in his summary.

2) "Animals given a standard dose of meprobamate at 24 hours cannot be imprinted at 26 hours, even though they do not show the fear and avoidance behaviour ordinarily exhibited at that age." This appears to support the notion of a species-specific critical period for imprinting, but it does not support an interpretation to the effect that the critical period is ended by the development of fear and escape tendencies which give rise to behaviour incompatible with following (Hinde, Thorpe, and Vince, 1956; Hinde, 1955;
Hess, 1959; Moltz, 1960).

(3) "Meprobamate appears to extend the critical age for imprinting. Animals given meprobamate at twelve hours can be imprinted fairly successfully at 24 to 26 hours, when the effect of the drug has worn off." Hess interprets this as being due to a slowing effect of the drug on the metabolism of the animal. These animals, at 24 to 26 hours, were functionally similar to untreated animals roughly 16 hours old, as it were.

(4) Chlorpromazine, given at 24 hours and followed by imprinting at 25 hours (i.e., corresponding to the conditions of (2) above, but with a different drug), allowed imprinting to be effected at 24 to 26 hours. In interpreting this result, Hess refers to the earlier finding that the strength of imprinting is a function of the effort expended or of the distance travelled, and states:

It may be that, since meprobamate is a muscle relaxant, these effects of meprobamate cut into the muscular tension or other afferent consequences and thus nullify the effectiveness of the imprinting period. Since, under the same circumstances, we attain perfectly good imprinting in all cases with chlorpromazine, this notion becomes even more tenable.

Weidmann (1956) also reports results that do not support the suggestion that the critical period is limited because of developing fear and escape behaviour. He confirms that the stimulus situations which Fabricius (1950) found to
elicit following, are effective, and also confirms the data on the critical period for Mallards, but he says:

This period was not due solely to an increasing escape tendency inhibiting the following: 40 hours old ducklings though not frightened would not react any more when called.

He adds that:

The underlying process (i.e., the process underlying imprinting, P.J.D.) takes a brief time, and does not occur at the beginning and at the end of the sensitive period.

Weidmann observes that the behaviour of imprinted and non-imprinted animals, in the absence of the releasing stimuli, is very different. An imprinted duckling stops other activities and searches; the non-imprinted one shows no such appetitive behaviour, "it has lost (or never gained) this urge to be near a parent." That birds who have been following a target-object run around and/or stand with head up and moving about, and give loud distress calls if that object suddenly ceases to move when it is distant from them and if they were not looking in its direction at the moment when it stopped moving, will be seen in Chapter III. In this context a study by Collias and Collias (1956) on the behaviour—particularly the calls—of ducks and ducklings under natural conditions is relevant. The two kinds of duck (surface-feeding and diving), were observed from hides from before the ducklings were hatched and for some
days afterwards. They note, inter alia, that there was a period of at least 18 hours before the mother duck and her young left the nest together.

This quite prolonged period of association in the nest provided considerable opportunity for the mother and young to become conditioned to each other.

When the mother left the nest (during this 18 hour period) abruptly, the young made no effort to follow her. The leaving of the nest by parent and young together was a gradual and drawn-out process in the case of the ducks with their nest over the water, but it was relatively quick with the other species. When a duckling became separated from the rest of the brood, it gave distress calls; when it rejoined the brood it gave contentment calls. The parent gave attraction calls more loudly and rapidly when the brood was actually leaving the nest, and, these authors note, the young do not necessarily follow the parent as soon as she leaves the nest, even when she calls them (Cf. Fabricius, 1950, on "successive stimulus accumulation"). This attraction note of the moving parent, compared with the other calls of the species, was relatively soft and low pitched, and consisted of brief, rapidly repeated, monosyllables of low intensity, (Cf. Collias and Joos, 1953).

With regard to the following response, Collias and Collias conclude that both sound and movement are important factors in its elicitation, and that the best time for its
development is on the first day (see Collias 1952, Fabricius 1950). Below five hours of age, the ducklings' legs appear to be too weak for following to be accomplished, and ducks older than 24 hours show a marked fear response to any large approaching object, hence these authors agree with the previously mentioned suggestion that these factors limit the duration of the critical period (see also Hess, 1959). An observation of some interest is that two ducklings, which were three days old and had not been "trained to follow," followed a silent moving human if they were placed with two other ducklings that had been trained to follow. It is presumed that the two "naive" ducklings had not been in the company of other ducklings prior to this occasion, since, if this had been the case, the naive ducklings might be said to have been imprinted to the others, who, in turn, were imprinted to humans, which would account for the observed behaviour.

Collias (1957) describes and analyzes the process of socialization in sheep and goats, which shows some similarities to imprinting. He reports on several parturitions, and the first few hours thereafter, in particular, in terms of the mother-child relationships, bringing out the fact that much of the behaviour is of a reciprocal nature—for example, a parent will answer the cries of an infant with its own cries, and will move towards it. He finds that a lamb or kid, removed from its mother at birth, and kept away from her for two hours or more, will probably be
rejected when it is returned to her. (Cf. Alley and Boyd, 1950.) ("Rejection" means that the mother withdraws from the neonate's nursing attempts, and butts it away when it approaches.) Collias believes that

...the probable reasons for the critical importance of the first few hours post-partum in the establishment of the social bond between mother and young in sheep and goats are: (1) facilitation by attraction of the mother to the fetal membranes and birth fluid, as well as to the young one itself, (2) maternal drive is apparently highest at, or near, the time of parturition, and (3) a very rapid learning process results in early fixation of the female on her particular young.

Some aspects of later social development are also described, including the reduction in the frequency of nursing, the appearance of aggressive and sexual behaviour, and the persisting companionship in mature life. This is generally comparable to the same author's 1952 paper (see above) in which he discussed the development of socialization in birds.

The importance of an organism's early social and perceptual experience for its subsequent social and other adaptive behaviour is emphasized in a paper by Melzack and Thompson (1956). It will be recalled that the work of Scott and Marston (1950) on periods critical for the development of normal, as opposed to mal-adjustive, social behaviour in dogs, was carried out with normal, variable, and unrestricted conditions of visual and social stimulation; this study by Melzack and
Thompson involved the restriction, to a number of different degrees, of the dogs' social and perceptual experience. Some dogs were reared freely as pets, while, at the other extreme, some were kept, in social isolation (from both other dogs and man) and with perceptual restriction, in cardboard-covered cages for between seven and ten months. At the end of this time all the dogs were given a series of tests of social behaviour:

Tests for dominance showed that the restricted dogs were strikingly inept in a competitive situation, as compared with the high degree of dominance behaviour displayed by the normal controls. Similarly, the restricted dogs did not exhibit the sustained, well-oriented curiosity towards other dogs that was observed in the control dogs. The restricted dogs were unable to accept and reciprocate the friendly approaches of a 'friendly man', or avoid physical contact with a 'bold man' in the unexcited, well-organized manner typical of the normally reared dogs.

The experimenters conclude:

Restriction of early social experience has a definite retarding effect on the emergence of normal, adult, social behaviour in dogs.

Very little is known, as yet, of the internal aspect of such restrictions (e.g., the physiological differences which may be caused by such conditions, and which mediate—in part at least—the observed behaviour). These findings are, of course, meaningful in their own right without such complementary data.
The work of Hinde, Thorpe, and Vince (1956; see also Hinde 1955) has already been referred to in connection with the critical period and the development of incompatible escape tendencies; it contains much important evidence on the possibilities of stimulus generalization. The experiments were performed using a large (24 yards by 6 1/2 yards) grassy area, with slotted fencing around it. Objects could be moved along inside this area on a quiet or a noisy pulley. Sometimes a human served as the target-object, silent or calling as he walked about the area; on a number of occasions a man would walk with a hide over himself and material trailing from the bottom of the hide to the ground, so that no part of his body could be seen by the moorhens or coots used in the study. These authors found that several different objects elicited following, as long as they were in motion. Birds could be trained to follow different objects on successive runs. Birds trained on one model would generalize to others presented in the same circumstances throughout almost the entire period in which they would follow at all—this clearly repudiates the suggestion that imprinting is irreversible (e.g., Lorenz, 1937) if by this is meant 'no stimulus generalization possible' (see page 514 above). With massed trials, however, the following of a familiar model was maintained at a steady level, while that of an unfamiliar one declined irregularly. The suggestion that following may be self-reinforcing has been noted earlier in connection with this work, and it is made use of in the hypothesized explanation of
this finding. They propose that following a familiar object brings more reinforcement than following a strange one. Moorhens were more likely to follow if tested on the first day than if tested subsequently, when they tended to flee; these birds also showed a stronger response to the hide than did coots—the authors suggest that this is due to the "shelter" characteristics of this object. In addition to this, Moorhens generalized to unfamiliar objects less readily than did coots, who were the better followers, whose day-to-day following scores remained steadier, and who were less affected by changes in the environment. It is clear that, whatever causal explanation is offered for imprinting, and whatever variables, hypothetical or otherwise, are invoked, there is positive evidence that the characteristics of the behaviour observed in these situations does vary between species.

The most systematic investigation of the various aspects of imprinting is the series of experiments reported by Jaynes (1956, 1957, 1958(a), 1958(b)). The first of these papers reports studies on development and generalization. The target-object moved, on a pulley system, at a speed of one foot per second, in a straight runway, with two 8-second pauses, and one 30-second pause, per minute, after 4 seconds, 16 seconds, and 30 seconds, respectively; there was also a 2-minute pause after each 5-minute period. The subjects were chickens (New Hampshire Reds), taken from a hatchery at between one and two hours of age,
and housed collectively. The measure employed was the time spent within one foot of the target-object. The distance followed cannot be calculated from this measure plus the known speed of the object, since Jaynes notes that most of the scores accumulated during the pauses. An estimate of the chance score was obtained, which was taken into account in the results. No sound was used as part of the stimulus; the target-object was a red cylinder or a green cube, which moved two inches above the floor; each session lasted for half an hour, before which the chicken remained in the runway for one minute before the target-object began to move. The two-minute pauses were rest periods, and are additional to the thirty minutes.

The behaviour of the chicken in the presence of the target-object included the following components: attention to the target-object; vocalization (satisfaction versus distress calls); approaching; and following—usually in that order. The general trend of the scores was upwards during each successive 5-minute period of the session (from around 60 seconds during the first 5 minutes, to 104 seconds during the last 5 minutes). Very young birds showed poor locomotion, and only short periods of sustained attention. Jaynes points out that this would account for their poorer scores. The tests were continued for four days. When the scores obtained during the last 5-minute period of each day's session were compared, they were found to have risen from about 141 seconds to 242 seconds, for the green
cube, and from 124 to 215 seconds, for the red cylinder. Based on the TOTAL SCORE for each day, the green cube was followed to a significantly greater extent \( (p = 0.05) \) than was the red cylinder. By the fourth day, the following was consistent and vigorous:

Whenever the object moved, the bird chased; when it paused, the bird always stayed close, usually uttering contentment notes and pecking, as though feeding, at the floor (no food present).

Thus the behaviour, as measured in this way, improves on subsequent trials; consistent following is not observed at first, as has been implied, at least, in most of the other reports referred to, but rather requires, as Jaynes suggests, the strengthening, through maturation and use, of the organs involved in running. That these results depend upon this particular measure is clear; it does not necessarily mean, however, that the effect of the moving stimulus was accumulating from day to day in the sense that this was the 'cause' of the improved performance. Since this measure reflects mainly the improved ability of the bird to run, there is no evidence that the initial exposure was less effective than were subsequent ones.

In another experiment, the target-object was switched, on days three and four, during part of the 30-minute sessions—the original object was presented both before and afterwards during the same session. There was a significant decrement
when the bird was following the 'wrong' object (p = 0.05), also, the decrement following the switch from the red cylinder to the green cube was significantly greater than the decrement following the switch in the reverse direction. This suggests that the red cylinder had the greater effect upon the bird than the green cube, which is further implied by Jayne's note that two of the birds trained to the red cylinder fled from the green cube when this was presented—each time it approached they fled along the walls of the alley, uttering distress calls. No fright of the new object (the red cylinder) was observed in birds trained first to the green cube. This conflicts slightly with the earlier result (that there was somewhat better following of the green cube), unless following were conceived of as a positive function of anxiety (see Moltz, 1960). Upper limits to this would be necessary, however, as otherwise, the bird would show its fear of a moving object by remaining continually near it! In a choice-discrimination test, the birds always went to the object to which they had been imprinted. As the objects were motionless, and as the chickens took about half a minute, after being released, to make their choice (even though they had been able to see the two objects for one minute before being released), this confirms, as Jaynes notes, that motion is of crucial importance as a characteristic of the target-object (see James, 1960, on flicker and imprinting). Before they made their choice, and after being released, their behaviour included distress calling, pecking, and "standing
about"—there was never an immediate rush to the object. The higher followers (group scores) took significantly less time than the others to make their choice. These results, like those of Hinde, Thorpe, and Vince (1956), do not support the contention that imprinting is irreversible in the sense which implies that no generalization is possible. They say nothing directly about the later stability of the response with respect to the original target-object—the other meaning of 'irreversible'.

In his 1957 paper, Jaynes reports on investigations of the critical period, which have some bearing also upon the problem of response stability. The general method and procedures were the same as before. There was only one target-object (the green cube); the birds were initially exposed at varying ages, at which time their response-strength was recorded; they were re-tested ten days later. The imprinting criterion was that the bird should follow for at least sixty seconds of the 5-minute period (the final period in the 30-minute session). Below this level the behaviour was attributable to chance factors. As a control, two groups of seven birds were initially exposed on the 12th and 13th day after hatching.

Jaynes found that a higher percentage of younger birds reached the criterion. Fifty-four-hour old birds showed no following. As older birds were used, so the mean following
score improved (although less birds were reaching the criterion).

On the "juvenile" re-exposures (i.e., ten days later), whereas 83% of the youngest group on the initial exposure reached the criterion, only 33% now did so. A similar decrement was found with the next group (i.e., birds initially exposed at a slightly older age). In all groups whose initial exposure was at or after 24 hours, the re-exposure score for incidence was improved. For example, although half the subjects, initially exposed on the second day of life, showed no evidence of imprinting at that time, 10 days later all but one of them followed vigorously. This phenomenon is termed, by Jaynes, 'latent imprinting'; it refers to the effects of neonate experience that do not manifest themselves until later. In the case of the control groups (who were initially exposed on days 12 or 13) the incidence of those reaching the criterion was zero.

Although Jaynes calls attention to the fact that behaviour in the imprinting situation includes far more than just following, he uses only this aspect of it in setting up his criterion of imprinting. This is reasonable, from one viewpoint, since this aspect lends itself more easily to measurement than do the other types of behaviour observed. Since, however, the criterion is limited in this fashion, the term "latent imprinting" has meaning with reference only to the
following-behaviour, and it cannot be decided whether the initial exposure affected any of the other aspects of behaviour which might well warrant inclusion in the same category as the following-reaction. More of this later, when the observations made during imprinting sessions have been presented.

With reference to those birds that did follow as neonates, it was the younger ones (at initial exposure) which "forgot" (i.e., did not follow) on the second exposure, 10 days later. In fact, more than half the birds initially exposed before 12 hours of age "forgot" on the subsequent exposure, whereas none of the birds, initially 24 hours or older when exposed, forgot on the second occasion. Since the initially younger birds showed a higher incidence of following at that time, this might appear surprising, but when it is recalled that these younger birds, despite their higher incidence, showed less strong reactions, if and when they did follow, than the older ones, the fact that more of them subsequently "forgot" is to be expected. In a typical memory experiment, the retention score is usually positively correlated with the degree of original learning, other things being equal (see Osgood, 1960, page 556).

Jaynes points out that these results indicate that there may be two critical periods, one in which incidence will be highest, the other in which the effects of the imprinting will be maximal, (as seen when the birds are observed again
later in life). This interpretation enables the apparently divergent results of Fabricius (1951) and of Ramsay and Hess (1954) to be reconciled. Fabricius obtained similar results as Jaynes for incidence, while Ramsay and Hess obtained a curve similar to that of Jaynes for retention. Not only is there no contradiction, but also there is both independent confirmation for Jaynes's results, and considerable support for his interpretation.

The critical period, Jaynes comments, may depend upon not only the species and the imprinting procedures adopted, but also upon the way in which the animals are incubated and reared, the nature of the stimulus, the duration of the imprinting session, and so forth. Thus any given set of results must be interpreted relative to the particular group of animals, and to the conditions and procedures of the investigation. Negative evidence for Hess's hypothesis (e.g., 1959), that the end of the critical period is determined by the appearance of flight reactions incompatible with following, is provided by Jaynes. He states that some of his chickens fled on the third day, but were nevertheless imprinted, while others, who did NOT flee, were still not imprinted. Also, those (control) chickens, initially exposed on the 12th or the 13th day, rarely showed fear but neither did they follow. Thus, the determination of what is involved in the critical period is by no means simple.
Hess (1959) found that chickens' locomotor ability increased steadily from hatching to about 16 hours thereafter; it then levelled off. The curve for the incidence of fear behaviour starts at about 10 hours and rises to its maximum at 30 hours after the chick hatches. By plotting these two curves together, one finds that an area between the two curves is arrived at which corresponds fairly closely to the area contained beneath the curve for the incidence of imprinting at successive ages of initial exposure. The actual curve for imprinting incidence is slightly more narrow than that obtained by plotting these other two together—Hess suggests that this might be due to the relative unsuitability of the models used in obtaining it. These curves cannot be said to support the hypothesis in question since they are but a more exact presentation of the data which gave rise to the hypothesis. It is true that the correspondence between these curves implies, at least, that the suggested relation between locomotor ability, development of fear behaviour, and the critical period might well be veridical; the negative evidence reported by Jaynes (1957), however, as well as that of Weidmann (1956), and of James (1959, 1960), must also find explanation, and it is difficult to see how this can happen within the framework of Hess's explanation.
Jaynes (1958, a) provides further evidence that imprinting does not differ from learning. He found that increased practice, with maturation controlled, leads to the following results:

1. The incidence of animals reaching the criterion is higher during the last five minutes of a long exposure than it is during the same period of a short one.
2. In these periods, strength of following increases in the long-exposure groups.
3. Tested at thirty and seventy days of age, the animals which initially had the longer exposures show stronger following than the others.
4. Longer initial exposures lead to fewer fear responses on these subsequent tests.
5. Warm-up effects are observed when imprinted birds are tested after an interval, and
6. Sex-difference is not a significant factor.

These differences (except the last) were statistically significant. Jaynes notes that chickens under barnyard conditions do not show, at these older ages, such attachment to the original imprinting object (in this case, the parent). He suggests older chicks look more like the parent, and "filial following becomes submerged in general gregarious grouping" (p. 236). While visual distinctiveness may be relevant, it should be noted that the experimental chicks did not see the green cube in the
interval, whereas barnyard birds remain with the parent continually—thus habituation may well account for the poor filial attachment of the barnyard animals, rather than lack of visual distinctiveness.

In his second 1958 study, Jaynes found that, when a second target object replaces the first one, a decrement in following occurs—except on the first day, when following scores to the first object are still low. This result is comparable to an earlier one (Jaynes, 1956). The magnitude of the decrement varies between individuals, but remains approximately stable for each individual over a period of four days—it is NOT related to the strength of following the more familiar object. The relative amount of generalization, based on group scores, similarly remains stable, between the second and fourth days (the animals being tested once per day). With regard to discrimination between the familiar object and a less familiar one, on the fifth day, the significant finding was not simply that discrimination occurs, but that it emerges as the bird remains in the runway, with both objects moving in the same fashion. At first the animal may respond to both the familiar and the "new" object, but after about thirty minutes, it is responding to the familiar one almost exclusively. This discrimination occurred more rapidly with the birds which showed less generalization during the earlier part of the experiment (i.e., during the first four days of testing).

The work of Moltz and Rosenblum (1958) will be referred to in Chapter IV, in connection with Moltz's theory on imprinting.
James (1957, 1960) found that chicks would approach a stationary object placed near a flickering light at one end of a runway. When the chicks, at seven days of age, and with practice at the above behaviour on five successive days, first saw the object move, they followed it, much as chicks follow moving objects in the usual imprinting situation. An important point was that the normal critical period for chicks (roughly up to two days) was thereby extended. James was able to show, further, that the behaviour in this flicker-imprinting situation varied in strength as a function of age (at initial exposure) and of rate of flicker. A high flicker rate was more effective than a low one, and chicks who were 24 hours old at the time of the initial exposure performed more strongly than 7-day-old chicks. It is suggested in the earlier paper that flicker and movement, due to the characteristics of the chicken's eye (see also Moltz, 1960), are perceived in essentially the same fashion, in which case the flicker-imprinting situation would be hardly different from the typical imprinting one. If this is so, then James's results indicate that overt following, or the expenditure of effort (Hess, 1956/57) is not essential for imprinting to be effective. A similar negative conclusion follows from the results obtained by Moltz, Rosenblum and Stettner (unpublished, cited by Moltz, 1960). These investigators kept Peking ducks in an apparatus designed to restrict their movement, but allowing a clear view of the moving target-object. After three, 25-minute exposures in this apparatus
(one per day), the ducks were subsequently released and "responded in a manner indistinguishable from control Ss that had been actively pursuing the object for an identical period of time." It would be interesting to set up an apparatus whose walls could be made to move around, while the target-object remained still. The young birds could either be confined a short distance from the target-object, and then released, or they could be allowed to move freely from the start. Would they move to the target-object or to the moving walls? If they moved to certain target-objects, but not to others, the most effective objects could be established, at least, and this might provide further evidence with regard to the hypothesis that energy-expenditure is both necessary for following and positively correlated with the effectiveness of imprinting. Hinde (1961) points out that:

Under natural conditions, the behaviour patterns operating between parent and offspring are complex and diverse, and there are innumerable opportunities for associative conditioning to the mother during following, brooding, feeding, etc. As a result of these a personal knowledge of the parent is built up in which the eliciting stimuli for the various discrete responses are united.

In contrast with this, he notes that:

In captivity, the various juvenile responses may be attached to diverse objects, so that conditioning to a parent-companion does not occur. This suggests that the 'parent-companion' is merely a consequence of the mother's presenting stimuli for the
various juvenile responses, and not of any inherent mechanism in the young.

In connection with the properties of objects to which the behaviour of young animals in captivity will be directed, Hinde refers to Harlow's (1959) finding that "conventional rewards are of little importance." It is worthy of note, however, that cloth will hold more heat than will wire, and that a cloth model presents a more continuous, and therefore greater (in extensity) degree of warmth than does a wire model—assuming that the temperature (i.e., intensity) of the two models is the same. This might well be a factor in the preference shown by Harlow's monkeys for the cloth models. The relevance of temperature changes to imprinting will be discussed in Chapter IV.

It will be clear from this review of the literature that, while imprinting has been extensively investigated in the last decade, there are few examples of intensive analysis. As a result of this, not only has the phenomenon been made to include an extremely wide variety of forms of behaviour (e.g., Thorpe and Zangwill, 1961), and not only have at least three different theories been proposed to account for it (Chapter IV), but also, and in spite of both these situations, the nature of its underlying process or processes, and the identity of its components, have not been established with any great degree of assurance. Although it is not uncommon for the explanation of
a given form of behaviour to remain elusive, the description of its components is usually beyond dispute. It may happen that "motivated perception" leads to bias in assigning relevance to behavioural components, while ignoring or discounting others, or, on the other hand, some components may be more obvious or more quantifiable than others. It appears to the writer that the latter condition applies in the case of imprinting. It is necessary, therefore, to establish what effect an artificial imprinting procedure has on the normal behaviour of the species. To do this, the behaviour of animals in the experimental situation must be fully described, as must that of animals in a more natural setting. Until the behaviour in a relatively free environment is known, the effect of the experimental procedure on the animal cannot begin to be understood.

The problem with which this research will be concerned, then, is to describe the varieties of behaviour of newly-hatched chickens, under several different stimulus conditions outside the experimental situation, to do the same for the behaviour of comparable chicks in the imprinting situation, to compare the behaviour observed in the two situations, and to consider the adequacy of the theories which have been proposed to account for imprinting, in the light of these findings.
CHAPTER II

METHODS AND PROCEDURES

A. OUTSIDE THE IMPRINTING SITUATION

(1) SUBJECTS AND THEIR INITIAL TREATMENT

The subjects of this observation were (a) 20 chicks of undetermined sex from the following species: New Hampshire, and White Leghorn, and (b) 4 broody hens, a cross between White Cornish and White Plymouth Rock, a different one for each of the respective groups. The broody hens were taken by hand from their outdoor houses, in which there were laying/nesting boxes and several other hens (usually approximately six per house). Most of the other hens in the house were not broody, and the hen used had been laying up to within about one week of its removal for use in this study. None of the hens had ever hatched or reared a brood of chicks. They were approximately one year old, and were removed by an experienced poultry man. This minimized the disturbance to the hen, who, nevertheless, was clearly aroused to no mean extent by her removal. She was carried indoors, to the room in which the apparatus was set up, and placed in the observation pen, with one or more chicks.

The chicks were hatched in a forced air incubator, the eggs being placed in individual wire-mesh cages two days before they were due to hatch. The temperature in the incubator was 92 to 94 degrees Fahrenheit, and the humidity was between 82
and 84 per cent. There was a small glass panel in the door of the incubator, which allowed some light to enter. The chicks were taken out of the incubator at, or soon after, hatching; the top of each wire cage was opened, and the shell was removed; the chick was then carried in the wire cage to nearby scales, removed by hand from the cage, placed on the scales, and returned by hand to the cage. It was carried, in the cage, about 40 feet, and placed in the observation pen, where it was removed from the cage by hand and placed underneath the lamp. One chick, in one of the groups, was indistinguishable from another in the same group, so it was marked with a piece of white tissue-paper, fastened to the middle of its back with adhesive tape. On its journey to the observation pen, the chick passed through a room in which a large number of hens and some cockerels were individually caged, and who were continually engaged in producing the vocalizations regrettably typical of their kind. If the chick, or group of chicks, was to be observed in the company of a broody hen, the hen was brought to the observation pen ten minutes after the arrival of the chick(s). In the case of a group of chicks the cages were carried one on top of another, with one chick inside each.

The temperature in the observation pen was 95 degrees Fahrenheit underneath the lamp (plus or minus two degrees), and about ten degrees below this at the furthest point in the pen from the lamp. Humidity was not measured, but it was considerably
lower than in the incubators. The bulb of the 60-watt reading lamp was positioned about five inches above the floor of the pen and the shade was inclined so that the light and heat from the lamp were reflected slightly forwards (i.e., in the direction of the observer's usual position) as well as downwards. The lamp remained on both by day and by night. The main lights in the room were never switched on, but the illumination varied with the time and type of day or night, as windows were found in one wall of the room, near the observation pen. Food and water were always present in the pen.

(2) APPARATUS

The floor of the observation pen consisted of the top of a large wooden table, six feet by four feet in area, and three feet above the floor. Walls of chicken wire, supported by a wooden frame, were nailed to the sides of the table on all sides, and extended upwards for three feet. The roof was similar to the walls, and could be slid across the top of the wooden frames supporting the walls; it was of the same area as the floor of the pen. Along one end and one side of the pen, on the outside of the wire walls, black plywood sheets were nailed. The one at the end covered the entire width of the pen, and extended upwards, from the level of the floor of the pen, for two and one-half feet. The plywood at the side joined this end piece, and covered one wall, along the length of the pen, except for a space of eight inches; it, too, had a height of
two and one-half feet above the pen floor. The other side, the other end, and the roof of the pen, had no such plywood, just the chicken wire mentioned. These will be termed "open". The open end of the pen faced the windows, standing six inches from them. The bottom of the windows was 24 inches above the level of the floor of the pen. The open side of the pen faced a large piece of unused wooden equipment along its entire length; the equipment extended upwards for two and one-half feet above the floor of the pen--above and beyond this was one of the white walls of the room. The pen was six inches from this wooden equipment, which, like the floor of the pen, was dark brown in colour. At one point above the closed side of the pen extended a stick, on which was placed a silver-coloured microphone, with a black trailing lead disappearing from the chickens' view downwards outside the black plywood on that side of the pen. A black electric cable, with a grey extension socket-box, lay on the roof, and a piece of brown flex ran from this across another part of the roof, and down, through one of the holes in the chicken wire, to the lamp on the floor of the pen. The lamp was of brown metal, with an adjustable arm, and a heavy base. The inside of its metal shade was silver-coloured, the outside being brown like the rest of the lamp. The area on the floor below and slightly forward of the bulb, onto which the light and heat were focussed, was circumscribed by a continuous chalk mark which thus delineated a circle of six-inch radius, referred to as area one. Beyond this circle, and concentric with
it, two further circles were marked, three inches, and six inches outside the first—these are areas two and three respectively. The base of the lamp was in part of area three, and the bulb was above area one, as mentioned earlier. Three inches to one side of the base of the lamp, also in area three, was a small Petrie dish containing water (this is called "the small dish" in the descriptions of behaviour), three inches to the opposite side of the lamp, again in area three, was a larger glass dish, three inches high, also containing water (mainly for the hens, while the smaller one was provided for the use of the chicks). On the opposite side of area one, once more in area three, were two further dishes, similar to the first two, containing food. Some grains of food were scattered all around the intervening (and other) areas, and whenever the water was changed (nightly), some of it was allowed to fall on the floor near the two water dishes. As three large holes had been drilled at some earlier date, into the table, which constituted the floor of the pen, three thin pieces of wood (approximately six by four by one-quarter inches) were nailed over them. These were well outside area three, and one of them (near the observer's usual position) will be referred to in the descriptions of behaviour, in connection with the relative ease with which the animals mounted it.

Outside the observation pen, on the closed side, was a smaller table, with a chair and a stool on it. These were used by the observer in the course of his observation. The chair
was positioned in such a way that the observer could speak into the microphone above the wall of the pen, without taking his eyes off the animals; the stool could be used to rest paper, etc. on while making written notes. As the floor of the room was of concrete, the legs of this smaller table were cushioned with several paper towels, to reduce the chance of them scraping along the floor, thus making a sudden loud noise. The chair and stool-legs were similarly cushioned. To this same end, the observer removed his shoes when in the observation room, and the door into the room was always moved gently. The black plywood on two of the walls of the pen enabled the observer to move around the room without disturbing the chickens. The side table (with the chair etc. on it) was positioned three inches from the observation pen, which allowed the observer to step onto it without jarring the pen. The top of the observer's head appeared above the plywood when he watched the birds, or, occasionally at the side of the plywood running along the length of the pen (with the gap of eight inches). A tape recorder was placed on a third table, six feet from the observation pen, on the "closed" side.

(3) PROCEDURE DURING OBSERVATION

After the subjects had been placed in the observation pen, as described above, (which required the observer to stand on the table outside the pen--this table to be called the
observation table—with both arms and one leg reaching into the pen), the observer stepped out of the pen, slid the roof over the top of the pen, climbed down and switched on the tape recorder. The roof made a fairly loud noise when it was moved, and the tape recorder gave a loud click as it was switched on—it was almost silent while running. The observer then stepped back onto the observation table, keeping his head below the top of the plywood, and sat on the chair, or knelt or squatted on the table. He then slowly raised his head to a position in which the subjects could be seen, and reported what he saw into the microphone, after first describing the group being observed and the age of its members. The behaviour was observed and recorded in this fashion in periods of twenty-five minutes, with a five-minute break between each of these. Occasionally, the observer would move off the table and observe from a different point above, or to the side of the plywood. At such times, he would be standing on the floor, and could just see over the top of the plywood. If observing from the side, he allowed only the smallest possible amount of his person to protrude beyond the plywood, where the subjects might see it, and, just as when observations were made from the usual position (i.e., on the observation table), the observer's head was moved as slowly as possible out beyond the plywood. The microphone could be moved from the stick above one wall of the pen, without jarring the pen. In addition to the descriptions spoken into the microphone, the observer, from time to time, wrote comments (usually a
comparison with the behaviour of another group) on the behaviour observed.

The food in the pen was changed only when no chickens were present—in other words, between groups. The pen was likewise cleaned between groups. The water was changed last thing at night, in the following fashion: a hose was pushed through the chicken-wire roof to each water dish in turn; the water was allowed to run for about one minute, which ensured that all the old water was forced out, and that new water took its place. The water which overflowed from the dishes ran to the near end of the pen, and fell down to the floor, flowing to a nearby drain. After this, the water was turned off, and the hose removed. The water dishes were thoroughly cleaned between groups.

(4) GROUPS OBSERVED

Table 1. List of groups observed outside the Imprinting situation. The groups were observed in the order shown.

<table>
<thead>
<tr>
<th>GROUP NO.</th>
<th>NUMBER AND TYPE OF MEMBERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/0</td>
<td>One chick with no broody hen.</td>
</tr>
<tr>
<td>1/1</td>
<td>One chick with one broody hen.</td>
</tr>
<tr>
<td>2/0</td>
<td>Two chicks with no broody hen.</td>
</tr>
<tr>
<td>2/1</td>
<td>Two chicks with one broody hen.</td>
</tr>
<tr>
<td>3/0</td>
<td>Three chicks with no broody hen.</td>
</tr>
<tr>
<td>3/1</td>
<td>Three chicks with one broody hen.</td>
</tr>
<tr>
<td>4/0</td>
<td>Four chicks with no broody hen.</td>
</tr>
<tr>
<td>4/1</td>
<td>Four chicks with one broody hen.</td>
</tr>
</tbody>
</table>
(5) OTHER RELEVANT FACTORS

a. Noise

During the entire course of the observations almost continuous noise was made by the many chickens including some cockerels housed in adjacent rooms. With the door closed, this was much reduced within the observation room, but when the door was opened it became momentarily much louder, until the door was closed again. Often a soft hum, from electrical machinery operated at the far end of the building, could be heard. For much of the day, a radio played in another part of the building—this could only be heard when the door was open, and then but faintly. When equipment was moved (usually by being rolled) from one part of the building to another, this could be heard—especially when it came close to the observation room. There was a telephone in an adjacent room, which sometimes rang, and, on occasion, one person might call to another in some part of the building. Several times a week, groups of school children would visit the poultry farm—these, too, tended to cause an increase in the noise level for a while. Sometimes someone, or something, would knock against a wall in an adjacent room. On three or four occasions, the door to the observation room was opened by someone other than the observer, and the other person spoke to the observer, from the doorway. Twice someone entered to fetch something from a cupboard.
The continuous noise of the nearby fowl constituted by far the most common source of noise. It was by no means loud,—when the hearer was in the observation room with the door closed, at least—but it served to mask most of the other, occasional, noises. The fact that the observer almost immediately habituated to it upon entering the room serves as a rough indication of its strength, or of its nuisance-value. This noise was much reduced at night. When the observer used the microphone, his voice was heard, of course, by the subjects.

b. Visual Disturbances

Neither the chicks nor the hens could see out of the windows at their own level—they could see the sky, and probably the roof of an adjacent building as they looked upwards through the windows. Their vision was not disturbed in any other way except by the hose, when the water was replenished nightly, and by the slow movements of the observer's head as it moved out from behind the plywood at the walls of the pen. To the observer's knowledge, nobody came close enough to the windows to be seen by the chickens in the pen, nor did anyone, other than the observer, look over the plywood into the pen, except when one of the staff of the poultry farm brought in the broody hens. There was scarcely any activity in the area outside the windows.

c. Smell

The usual sort of smell associated with a poultry farm pervaded the observation room at all times. It is thought not
to be important to any great degree.

d. Handling

The subjects were not handled except at the beginning and end of the period in which they were in the observation pen. Their initial handling was discussed earlier.

e. Length of Observations

Each group was observed intensively for at least two days. If the next group was not ready by then (i.e., when the eggs did not hatch quite on time), observations were continued. Since the observer frequently found that, if he attempted to watch in detail the behaviour of the chickens for a continuous period of more than about two to three hours, he began to miss possibly significant details, the observations were postponed after this length of time, and were resumed thirty to sixty minutes later. Likewise, observations were necessarily discontinued when the observer went home for the night.

B. IN THE IMPRINTING SITUATION

(1) SUBJECTS AND THEIR INITIAL TREATMENT

Twenty-six newly-hatched New Hampshire chickens, of undetermined sex, were the subjects in the imprinting part of this study. They were hatched in the same way as the previous
chickens, being taken from the incubator at between fifteen minutes and two hours after hatching. They were placed in separate covered cardboard boxes, or in separate compartments of a large covered cardboard box, which had holes in the roof for ventilation, and transported in the back of a car for about one mile to the imprinting room. They remained in these boxes, or compartments, which were numbered, throughout the whole of this part of the study, except when taken to the imprinting runway. In these boxes, the chicks could hear, but could not see each other. The temperature in their immediate vicinity was around 96 degrees Fahrenheit, and the humidity in the room was low. Food and water were always present in each bird's compartment or box, these were replenished at the end of each day. The room was generally quiet, with the occasional noise of people passing along the corridor which ran around three sides of the room (the floors were wooden) and of their speech at such times. The experimenter removed his shoes whenever he entered the room.

(2) APPARATUS

A wooden, black-walled, runway, eight and one-half feet long and two feet wide, with twenty-two inch high walls, was used. It was straight, and its floor was covered with wood shavings to an average depth of about one-quarter inch, although these tended to cluster, and so build up to almost an inch in depth. Two pulley wheels were situated, one at each end of the runway, at the top of the apparatus, being supported by black wooden
cross-members. A black pulley belt ran around and between the wheels, and the drive came from a variable-speed electric motor, just outside one end of the runway, being relayed by a black drive belt onto one of the pulley shafts. The motor made a slight hum when in operation. Suspended by a light-coloured thread from the pulley belt was a yellow plastic imitation golf ball (for the first group), or a vertical line of such balls (for the second group). In the latter case, a white ball was at the top, with a yellow ball beneath it, a second yellow ball beneath that, and a red, white, and blue banded rubber ball, of the same size as, but heavier than the others at the bottom of the line. These target-objects cleared the floor by less than one inch in the middle of the runway, and by about two inches under each pulley wheel. The runway had no special lighting as it was situated directly beneath two flourescent tubes in the (high) ceiling of the room. These ran across the runway, and, as both these and several other nearby flourescent lights were on during the day, the runway was well and evenly lit.

A continuous tape, with a human rendition of "Gock, gock, gock" was played on a tape recorder, at the times shown below. The tape recorder was placed in such a way that the sound was maximal in the centre of, and below, the runway. The volume was reasonably high.

In the runway the temperature was approximately 10 degrees below that in the chicks' living quarters, which were near a radiator.
(3) IMPRINTING PROCEDURE

The chicks hatched in two groups, three days apart. Thirteen chicks hatched and were used on the first day, the other thirteen on the subsequent day. The only difference in the conditions lay in the target-object, mentioned above. The second group of chicks had a mean age one hour greater (four hours) than the first group (three hours).

Each chick was taken by hand from its box, carried to the runway, and placed in the centre thereof. The target-object was motionless at one end of the runway, and no sound was coming from the tape recorder. After five minutes the recording of "gock" was switched on, and after two more minutes, the pulley was set in motion, with the "gock" still playing. This lasted for ten minutes, when the sound was switched off; then, after a further two minutes, the pulley was stopped near one end of the runway. The chicken remained in the runway for one final minute, when it was removed by hand, and returned to its box. The pulley moved at a speed of approximately sixteen feet per minute, completing one circuit in a fraction less than a minute. Thus, when the chick was in the centre of the apparatus, the target-object passed him twice each minute, at 30-second intervals; when the animal was at one end of the runway, it passed him once per minute; between these two extremes the object passed him twice per minute, each pair of passes being closer together, and separated by a longer interval, the nearer the bird
was to the end of the runway. The target-object swayed from side to side as it moved along the runway. The age at which an individual chick was exposed to the moving object varied from one and a half to six hours after hatching.

The experimenter observed the chick's behaviour by moving the top of his head and eyes above the top of the walls of the runway (which rested on a table), and at a distance of from two to four feet from them. He recorded the behaviour by means of symbols, and then wrote a full report immediately after the particular chick was returned to its box.

On the day following this initial exposure, the chicks were again placed individually in the runway for a period of ten minutes. No sound was used; the target-object was the same as on the first day, and was in the process of moving around a pulley wheel at one end of the runway as the chick was placed in the centre, facing that pulley wheel. The target-object did not stop moving during the entire period in which the chick was in the runway.
A. Outside the Imprinting Situation

The behaviour of the subjects was described as it occurred. The observer spoke into a microphone, and the observations were recorded on tape. Subsequently, these recordings were transcribed onto paper. Each thirty minutes of observation required approximately five pages when transcribed, and each of the eight groups was observed for about fourteen hours in all. Thus, to present the complete verbatim descriptions, over one thousand pages would be needed. Because of this, the behaviour of each group is summarized.

(1) Observations of the behaviour of a chick still inside the (chipped) shell.

The following written notes were made:

There is a small hole in the shell; the beak is protruding slightly through this hole, with the side of the beak pressed against the edge of the shell.

Only part of the head and upper body can be seen—there are rhythmic breathing movements involving the whole of this visible area.

The beak opens and closes fairly frequently—usually a series of 5-6 such movements is observed, lasting about 3 seconds, and followed by a pause, in which the beak is closed, of about 12 seconds' duration.

The head moves slowly and irregularly, to both sides, up and down, forwards and backwards. The beak sometimes goes back into the shell as the head moves.

The visible area of the chick often jerks two or three times. This continues at irregular intervals (approximately between 5 and 10 seconds), for most of the time.

On many occasions a single soft chirp is heard, or a short series of such chirps. This sound is the same as the soft chirps of newly-hatched chicks. There is usually a long interval between such chirps, or between the series of chirps.
The egg was moved forwards, by hand, and loud chirping was heard--6 chirps, louder and longer than the ones mentioned above. Approximately 20 seconds later, when the egg was still, there was another such series of loud chirps. Thereafter, the chirping was quieter, and the same as the earlier chirping.

The mouth continued to open and close more frequently at later periods; these movements were slower than similar ones of a newly-hatched chick.

(2) Behaviour between incubator and observation pen (all groups).

When the door of the incubator was opened, the chick would usually be lying in one corner of its wire cage. Its head was almost always turned towards the now-open side of the incubator; its eyes were open; and it was quiet. Sometimes it would be standing in the cage when E first saw it, or it would stand up (or at least push up on its legs) soon afterwards. As E put his hand into the incubator to lift out the wire cage, S would look upwards towards the approaching hand. The cage usually scraped slightly along the wire floor of the incubator as it was lifted forward--as it was brought forward, S would sway and/or shift its feet, probably to keep balance. The chick would watch E's hand as he opened the top of the wire cage, and reached inside to remove the halves of the shell. If the shell brushed against the chick, it would flutter to one side, and give a single moderately loud call, or a few such calls. As the chick was being carried to the scales, it usually lay down, with body flat, but head up, looking around. It might, however, stand, with head moving about. In both cases, the chick would remain quiet at this time. As E reached in to pick up the chick for weighing, it watched E's hand. It did not move from whatever position it was in, but as E took it in his hand, it would shuffle about, pushing itself backwards across E's hand, and giving several loud calls. If E did not get it successfully on this first attempt, it would run around the small cage as E reached towards it again. It was not uncommon for the chick to peck lightly at E's hand at such times. As soon as it was placed on the scales, it settled down, body flat, head at medium height (beak horizontal). As E lifted it off the scales and returned it to its cage, it would struggle in his hand; it usually made no sound at this time. Back in its cage, it would settle down immediately, body flat, head at medium height, looking all about, and it remained like this while being carried to the observation pen. One or two chicks would stand instead of lying in the cage, and, occasionally, one or more soft chirps would be heard. It did not show any particular response as it was being carried through the room in which the many older noisy chickens were individually housed. When E reached into the cage to lift the chick into the observation pen, it would usually struggle in E's hand,
and might call moderately loudly once or twice. It would lie down immediately, in most cases, or would stand where it had been placed—in either instance, its head would be held at medium height, and it would look around in several directions. At this time it made no sound. As E climbed out of the pen, the chick would, normally, turn and look in his direction. As the roof was slid over the walls, a noisy operation, the chick would stand up and move quickly forward, or around, a few paces, fluttering its wings, and calling loudly. This calling continued as E climbed down, switched on the tape recorder, and took up his position—by this time, or soon afterwards, the chick usually was quiet and lying down, with head up and eyes open, near the lamp.

(3) **Group 1/O; one chick, with no broody hen.**

Until about 3 hours old, S spent most of its time lying flat on the ground underneath the lamp. Its beak and head were stretched along the ground in front of its body, and its eyes were closed. Its back was towards the lamp. It would raise its head and open its eyes for a few seconds—infrequently—and would shift position slightly, from time to time, without standing. At these times a few soft chirps might be heard, while, for the rest of the time, the chick would make no sound.

As it grew older, the length of time it spent lying on the ground decreased. After such a period it would stand, stretch its whole body, flutter its wings, gape a few times, and move jerkily forward a short distance. Its legs, for the first few hours, were not straight underneath it, but were slightly bent. This meant that the bottom of its body was slightly lower than the top of its legs. Its head would be held mostly at medium height (i.e., beak horizontal), and would jerk slightly in several directions. If it stood still, its body would sway forwards and backwards, and to each side—on occasion, it would almost lose balance, but would quickly regain it, using its feet and wings in particular. Often its head would be held just above the ground, moving to the right and left as it stood or walked forward. At first, it rarely pecked at the ground, but within a few hours, this was done almost the whole time as it stood or walked forwards, or as its body lay on the ground, with head up.

When it walked, the leading foot would not fully advance to the front of the trailing one, so that it often lost balance, walked jerkily, and had slight difficulty in retrieving the foot that was partly pinned down by the other one. By about the age of 14 hours, it no longer did this.

Most of its pecking occurred in fairly long bursts, although shorter bursts, or single pecks, were observed during most of the time between its 'rest' periods. After each peck, or after
two or three pecks, its throat would move rhythmically for a few seconds, with its mouth remaining closed—this is referred to as "chobbling". After most pecks it would give a single soft chirp. A typical sequence was peck-chirp-chobble, repeated many times. Between a burst of pecking it would raise its head (beak above horizontal) and look around in several directions, and might walk forwards, or around, before resuming pecking, although it moved a little almost continually as it pecked.

As it raised its leg to step onto the Petrie dish containing most of the food (a lot was also scattered on the ground), or to step onto one of the raised pieces of wood in the pen (see the description of apparatus), it would often lose balance, and, on these occasions might actually fall onto the ground, although it immediately regained balance, by using its legs and wings in particular.

During these first few hours, if it was resting, the crowing of a cockerel in the next room, and the ringing of a telephone in another adjacent room did not disturb it—even though both these sounds were intense and sudden enough to startle the observer. If these occurred during one of its active periods, however, a startle response would be seen. This consisted of the following pattern: the chick would stop whatever it was doing at the time; its head would jerk up, and would be held, cocked slightly to one side, with eyes fully open, and mouth closed, and with beak well above horizontal. Its head would usually remain still in this position, or would, less commonly, jerk slightly to a different position, to the right or left. The chick would remain quiet and still. This response would last for no more than five seconds, unless the noise persisted in short bursts (e.g., the continued crowing of a cockerel). The chick would then continue with its previous behaviour, or would walk forwards a few paces, head at medium height, and looking around or towards the ground, before resuming its previous activity. This startle response was shown throughout the whole period in which the chick was observed; it was also common to all the chicks, and a similar pattern was shown by the broody hens in like circumstances. If the chick's body happened to be on the ground, it would first move its head, as described, and would often stand up as well.

Loud calling was seldom heard, after the chick was once placed in the pen. If the chick had moved well away from the lamp (this did not occur for some hours), and had remained there for several minutes, a few loud calls might be heard. At the same time, the chick would raise its head high into the air, look all around for some seconds, turning its body as it did so, and then run, with wings extended slightly and fluttering, back towards the lamp. It would then move slowly around beneath the lamp, for a few seconds, with head mostly near the ground, and then lie down under the lamp. A few soft chirps might be heard as it moved around
beneath the lamp. Such sudden runs were rare, and sometimes occurred in the opposite direction (i.e., away from the lamp, or at least, across the pen around area three).

The chick was seen to peck at the grains of food, at foreign particles on the ground, at the black plywood walls, at the head of the nails in the raised pieces of wood, at the side of the glass water dishes (apparently at the bubbles in the water), at the thermometer, at the base of the lamp, at the inside of the shade on the lamp, at the water in both the large and small dishes (never at the drops of water on the ground), and at its faeces. When it pecked at the water for the first time (several hours after being placed in the pen), it had been pecking at the side of the water dish a moment earlier—it appeared as though the chick was pecking at the bubbles in the water, rather than at the water itself, for, as soon as it had pecked into the water, it raised its head, and maintained the startle pattern for a few seconds, before chobbling, looking down towards the water again, and pecking into it several times more. When it pecked at its faeces, it would raise its head quickly, making a peculiar kind of soft squawk, open and close its mouth several times, shake its head vigorously, and flutter its wings, bringing them forwards, its head moving underneath one of them. This first happened when the chick was about $\frac{1}{2}$ hours old—it occurred again twice on the first day, several hours later, and once on the second day of observation.

The chick defecated very infrequently on the first day, somewhat more often on the second.

When the observer replenished the water in the two dishes, at the end of the first day's observation, the chick squawked and called loudly as the hose banged the wire of the roof. As the hose came down towards the water dishes, these loud calls continued, and the chick ran, from beneath the lamp, across to the far side of the pen, about 4 feet away from the water dishes. There it stood, watching the operation quietly. As the hose was pulled back up towards the roof, the loud calling began again, and the chick ran to the side of the pen. Within 2 or 3 seconds of the hose's disappearance, the loud calling ceased, and the chick moved slowly back to area one.

As the chick grew older, not only did it spend less time lying on the ground beneath the lamp, but also its movements (especially its standing, walking, preening and running) became better controlled, and less likely to lead to loss of balance. When it did lose its balance, this was regained before the chick's body actually hit the floor. Its walking became slower, and larger strides were used, with each foot remaining in the air for a longer period than at an earlier age. Its running was faster,
and more frequent. When it stood, it swayed less, its legs were straighter underneath it (hence its body was higher), and it remained standing for longer periods. When it preened in the standing position, it maintained much better balance.

During the first two hours, the chick shivered, and pulled its wings close into its body, almost continuously. This occurred less with increasing age, and was not observed after about five hours.

The chick's breathing movements seemed to involve, or to affect, almost the whole of its body, when it was very young—later, their effect was not so apparent, although the movements were still quite obvious.

As the chick grew older, the soft chirps became both easier to hear, and more common, especially as it moved about and pecked. The distance covered, and the distance to which the chick would move away from the lamp, increased with age.

As the observer began speaking into the microphone at the start of each twenty-five-minute period, the chick would show the startle pattern, then look in his direction. Within about five seconds, it would cease to orient its behaviour towards the observer, and appeared to pay no further attention to his voice—unless it had been lying down for several minutes, with the observer quiet, and then the observer had spoken again (e.g., to confirm that the chick was still lying down, or to record the fact that it had shifted position slightly)—on such occasions, the chick would show the beginnings of the startle response pattern, but would quickly cease to do so. If the chick had been lying down under the lamp from the end of one such observation period to the start of the next (i.e., a period of between 5 and 10 minutes) it would often stand up and begin to move around almost as soon as the observer began speaking again, settling once more within 1 to 2 minutes. It seldom appeared to hear the observer as he climbed onto the observation table, or to see his head as he moved it upwards above the walls of the pen.

Quite frequently, at all ages, the chick would preen, or peck at, various parts of its body, and scrape the side of its beak along the ground (this last item was not observed until the second day). Most commonly, the chick would preen behind one or other of its wings; almost as frequently, it would preen its breast; somewhat less often, it would preen its stomach between its legs, or at the inside of one leg. As it preened behind a wing, this wing would be pulled forwards, and the opposite wing would move outwards from the chick's body—its legs would be spread slightly further apart. After preening, it would usually shake its head once or twice, and open its mouth (gape) a few times.
Quite often, the chick would raise one foot towards its beak, and peck at any dirt etc. on the foot—on these occasions it frequently lost balance momentarily, and replaced its foot onto the floor as in regaining it. At all ages, the chick occasionally stretched one or other of its legs straight back behind it, clear of the ground, with foot spread out, swaying slightly forwards on the other foot as it did so, and stretching its head forward, mouth often opening. The foot would be held in this position for up to about five seconds.

(4) Group 1/1: one chick with one broody hen.

The behaviour of the chick was comparable to that of the one in group 1/0, with the following added features:

When the hen was placed in the pen, some ten minutes after the chick had been put in it, she clucked and squawked very loudly, flapped her wings, ruffled her feathers, jerked her head around sharply, looked up towards the top of the pen (as the roof was being closed), and walked over to the far end of the pen, away from the lamp, chick food, etc. She stood there, looking out of the wire netting, squawking and clucking intermittently, scratching her feet on the ground, feathers slightly ruffled and tail up. She continued in this fashion for several minutes, strutting along the wire, and occasionally placing one foot on the wire and hopping up onto and against it.

The chick showed a marked and prolonged startle response as the hen arrived (the hen made such a noise that any calls that the chick made were obscured). It had been lying under the lamp, with head up, and now stood up, watching the activity of the hen closely. It moved around on the same spot, as the hen walked to the far end of the pen, and, at this stage at least, gave no calls. As the hen moved around, it walked towards her, as far as area three, then stood looking in her direction for several minutes, occasionally looking in several other directions as well, and down towards the ground. It then turned and moved towards the lamp (approximately 5 minutes after the hen's arrival), pecking at the ground as it did so. In area one, it stood looking towards the hen for about 15 seconds (the hen was standing still and quiet, looking out of the wire, away from the chick), and then turned from the hen and lay down, with head up. It looked all around, then down at the ground in front of it pecked and chobbled three times, and then its head slowly sank towards the ground, with its eyes partly closed.

As the hen moved and clucked again, several seconds later, the chick's head jerked up, its eyes opened fully, and its head turned towards the hen. It watched her for a few seconds,
then looked towards the ground, pecked and chobbled once, then closed its eyes, with its head still up in the air and pulled back into its body. Similar behaviour was observed on the next few occasions when the hen squawked and/or moved around. The chick once stood up, turned further from the hen's direction, and lay down again, with head on the ground.

About fifteen minutes after the hen's arrival, she lay down at the far end of the pen, head high in the air, looking out of the wire. Thereafter she remained like this for almost the entire day. Occasionally she would give a few soft clucks, and would jerk her head around a little, especially if there was a sudden noise. Both the hen and the chick jerked their heads up at a noise, instantaneously, and in an almost identical manner. The hen, however, remained with head up for far longer than the chick. Once or twice during the remainder of the day the hen stood up, stretched, squawked and clucked, walked forwards and settled down again. She also preened herself upon occasion.

Just over one hour after the hen's arrival, the chick who had wandered into area three, away from the lamp, and in the hen's direction, pecking at the ground once or twice, stood at the outer edge of this area, and looked towards the hen, some three feet away. The hen had been watching the movements of the chick during this time, with neither of them vocalizing. As the chick slowly moved two or three paces farther towards the hen, she stood up, clucking, and looking towards the chick. She walked about five paces across the cage, obliquely to the chick, still clucking and watching the chick, with her tail ruffled and spread out behind her. The chick stood swaying as the hen stood up, watched her as she began to move, lost balance, quickly regained it, called loudly twice, and looked towards the hen, who by now was still. The chick slowly and irregularly walked towards the hen, sometimes looking towards the ground, and sometimes standing still. When about 18 inches from the hen, the chick stood looking towards her for a few seconds, then darted forwards to the side of the hen, near the front of its body. The hen, who had watched the chick the whole time, pecked at it once, then pecked again and lifted the chick in her beak, and tossed it away from her, some six inches. The chick gave a long loud call as the hen pecked the first time, shaking its head (the hen had pecked at the top of its beak, near one eye), and ran in towards the hen's legs. As the hen threw it forwards, the chick gave several more long loud calls, kicked its legs and fluttered its wings, as it struggled to stand upright. It stood, calling loudly, shaking its head, and preening its breast, for about 30 seconds, then stood quietly looking towards the hen (who was now strutting slowly away from the chick). It then darted about 2 feet towards the hen again, running under her body, between her legs, from behind. The hen again pecked at
the chick, and tossed it away from herself, turning as she did so, and the same thing happened about one minute later. Then the chick, after standing and calling loudly for several seconds, ran to area one, and stood quietly preening itself under the lamp. About 2 minutes later it lay down, head on the ground, eyes closed, and remained thus for almost 2 1/2 hours. Occasionally it shifted its position slightly, without getting onto its feet.

This approach behaviour, from the chick to the hen, occurred over fifty times during the rest of the first day. On each occasion the chick was pecked viciously, and was clearly hurt. Blood appeared at the junction of its beak and "forehead", and the observer was strongly inclined to terminate the observation. On some occasions the hen did not peck at the chick for about 10 seconds after it ran under her, and, several times, the chick was stepped on by the hen as she turned. When the hen's foot released it, the chick ran at least 2 feet from the hen, calling loudly, as it had done while struggling under her foot. The hen did not jerk her foot up as soon as she stepped on the chick, but rather kept it there for several seconds, with her weight on it as she moved her other foot. The chick, after this, would stand, calling loudly as it preened itself, for about half a minute, then would run or walk back to the lamp, soon to settle down beneath it.

When the observer left that night, the chick was lying under the lamp, with head down and eyes closed. The hen was sitting near the far corner of the pen, facing away from the chick, eyes half closed, head pulled back into her body. The apparent hostility towards the chick (no anthropomorphism is intended) had been maintained whenever the chick approached.

When the observer returned next morning, however, the hen was sitting in a corner near the lamp, with head up, clucking softly and intermittently. She looked upwards towards the observer as he raised his head over the plywood walls. The chick was nowhere in sight. The observer checked with the staff of the poultry farm to find out whether anyone had removed the chick. No one had been in the room, and it was subsequently discovered that the chick was underneath the hen.

Occasionally the chick's movements could be inferred from the movement of the hen's body--and wing feathers. The hen would, occasionally, shuffle around slightly at which times the chick, or part of it, might appear from under the hen, soon to disappear beneath her again. The hen clucked intermittently throughout the day, and occasionally pecked at the food scattered on the floor. The hen and chick stayed in this position throughout most of the day. Several times the chick came out, stretched, fluttered or walked about, pecked, defecated and looked all around, for a period of about 10-15 minutes. It then returned to
the hen. During the periods when the chick was out like this, the hen would bring its head down near the ground, stretching it forwards, and watching the movements of the chick. It might also preen itself, and shuffle around a little. Twice, during one of these periods, the hen stood up, ruffled her feathers, stretched her wings and neck, and walked forwards near the lamp. She spent about 15 minutes, mostly pecking from the large food dish, and also pecking into the large water dish, at the food on the ground, at her legs, and at the outer edge of the lampshade (metal). She defecated on each occasion and frequently clucked softly in extended bursts. After about 15 minutes she settled down in almost the same position as previously, and the chick soon returned to her. With the exception of these infrequent periods, the hen brooded the chick throughout the day. If there was a sudden disturbance, (someone opened the door, on one occasion, and spoke to the observer), the hen would show the previously described startle response, and would ruffle her tail feathers, shuffle slightly, with body raised a little, and cluck loudly and irregularly until the disturbance ceased. She almost always looked towards the top of the plywood walls at these times, and in the direction of the disturbance. The observer could seldom raise his head over the walls without the hen being aware of his presence (she would cluck, shuffle about, and ruffle her feathers slightly). The chick hardly ever saw the observer—or, at least, paid almost no attention to him. The broody hens in the subsequent groups noticed the presence of the observer far less than did this hen, as they remained at the far end of the pen looking outwards, while this one remained (on the second day) at the near end of the pen (where the observer usually was), looking inwards towards the lamp. When the observer spoke into the microphone, after remaining quiet for a short while, the hens would show a startle response pattern, but this usually ended within a few seconds, and the hens appeared unaffected by the observer's speech during most of the remainder of the time.

(5) **Group 2/0; two chicks with no broody hen.**

Both chicks were of the same species (White leghorn); the first to hatch (Chick A) was three hours old at the start of the observation period, the second one (B) was 60 to 90 minutes younger. A weighed 49 grams; B weighed 46.

The chicks' behaviour was generally comparable to that of the single chick in the first group, but was characterized by the following features:

The two chicks behaved almost identically and simultaneously. When one lay down, the other would lie down within a few seconds; when one stood up, the other would soon be standing, too; when both were lying, with head down and eyes closed, if one
looked up, the other would act likewise. Although B appeared to be the first to act more often than A, quantitative analysis would probably show no significant difference.

In addition to the preening and pecking movements found with the single chick, mutual preening and pecking were seen with this group. Sometimes, when one chick pecked the other, the second would not show any particular response, but often it would run quickly to a new position, some inches away, calling moderately loudly. There was no clear-cut border between the more gentle and the more forceful pecks, nor between the degrees of response of the pecked chick. A great many of the pecks were directed towards the top of the other's beak, just forward of the eyes, and these almost always elicited the slight fleeing response described.

The pair of chicks stayed extremely close together, especially on the first day—seldom more than about 4 inches apart, and mostly no more than one inch apart, or touching one another. When they were standing more or less still, or lying on the ground, one chick would often rest its beak and neck on the other's back and side. Another common form of contact consisted of one chick pushing its beak, head, and even body up to and under the other's body. If the latter chick were in a standing position, this would usually mean that it would be pushed forwards, or to the side, and upwards—in which case it would run forwards a few paces, upon landing, squawking moderately loudly, and then stand still again. If this chick had been lying at the time, it would be pushed onto its side and breast, and would usually stand up, move around, and settle down again against the side of the other chick. The chicks lay side by side, each against the other; almost invariably they lay under the lamp, and, like the single chick, they would mostly face away from the lamp, with their backs closer to it than their heads. As they grew older, they became slightly more independent of each other (in a purely descriptive sense), both in the form and timing of current behaviour at any given moment, but it should be stressed that this was only so to a slight degree. The distance between them tended to increase on the second day.

Throughout the whole of the period of observation, this group spent less time lying on the ground under the lamp than did the single chick. They were active for longer periods and had shorter periods of inactivity than did the lone animal.

It was the observer's impression that Chick B (the younger, lighter one) was more active and aggressive than A, and that it lead A more often than it was lead by the latter.

(6) **Group 2/1: two chicks with one broody hen.**

The chicks were both White leghorns, the hen was a White
Cornish cross. The younger chick (B) was one hour old, and the older one (A) two hours old, when observation began. They each weighed 50 grams. The behaviour of this group can well be described as being a combination of that observed in groups 2/0 and 1/1.

The group was more active than the first group (1/0); it contained all the elements found in group 2/0, as well as the approach behaviour of the chick to the hen observed in group 1/1. There were the following differences, however:

After the initial encounters with the hen, and having been viciously pecked by her, the chicks spent far less time near the hen than did the chick in 1/1. Thus, while the single chick in that group approached the hen at least fifty times during the first day, these chicks approached their hen only eight times on the first day. Seven of these approaches occurred in the first five hours of observation, and the eighth about three hours later. After that, on neither the first nor the second day did the chicks ever come closer than 18 inches to the hen, who, like the former one, spent most of the time sitting at the far end of the pen from the chicks, looking away from them through the wire. These chicks did not settle under the hen during the night (at least, they were not under her the next morning), nor at any other time. They behaved dually as did the pair in group 2/0. The observer could form no impression as to which, if either, of the pair was the more strongly dominant; Chick A approached, and was pecked at by, the hen on two occasions more than Chick B.

When they did approach the hen, they usually did so separately. One chick would remain about 18 inches from her, watching her and the other chick. This other one would move towards the hen's legs, from the side and rear (the hen would stand whenever the chicks came within about 2 feet of her). If the hen did not attack the chick immediately, the other one would follow it within a few seconds, when they would both be pecked at by the hen. If she tossed one of them away, the other ran from beneath the hen towards it, and stood near it. If the hen did attack the first chick when it first approached, the second chick would stay where it was, away from the hen, or move towards the first chick. They did not immediately return to the lamp, but spent several minutes walking, standing, looking around, preening (especially the one that had been tossed by the hen), and pecking. They then, at first at least, approached the hen again, but later, spent less time near the hen after being attacked.

Chick A bled slightly at the top of its beak after several attacks by the hen, and throughout the rest of the observation B pecked at this area. A would run from B when this
happened, calling loudly and continuously for about 10 seconds. They would soon be next to each other once more, either of them approaching the other, or both approaching simultaneously.

(7) Group 3/0: three chicks with no broody hen

This was a mixed group, containing two New Hampshires, and one White Leghorn. Chick A, a New Hampshire, was 3 1/2 hours old, Chick B, the White Leghorn, was 2 1/2 hours old, and Chick C, the other New Hampshire, was about one hour old, at the start of the observation. Chicks A and B weighed 49 and 48 grams respectively, and Chick C weighed 51 grams.

The behaviour of the chicks in this group contained no new items; it was characterized, however, by a somewhat different orientation than that of the previous groups, as follows:

When the three chicks were placed under the lamp, one of them (C) lay down almost immediately, and its head went onto the ground, with eyes closed, about 20 seconds later. A and B, however, walked around close together under the lamp for just less than 5 minutes. They looked all around, especially at each other, and pecked at the ground several times in this period. Chick B shook itself violently at one stage, almost toppling over, whereupon A ran forward away from it, about 6 paces. A quickly rejoined B. When they lay down, they did so side by side, about 4 inches from C.

Throughout the rest of the observation period, A and B acted as a pair (like the chicks in 2/0), while C remained relatively independent of them—this was by no means an absolute affair, however, for C would sometimes be close to the others and act as they were acting. Mostly, though, either A or B, or both, would run at and/or peck at C when it came within about 3 inches of them. In addition to this, A and B would often be showing one form of behaviour, while C would act differently. When all three were lying under the lamp, C would almost always be close to or touching either or both A and B, who usually lay down after C. It was when the three of them were not lying under the lamp that the subgrouping became far more noticeable.

Chick C spent far more time lying under the lamp than did A or B—often these two would be down after C had done so, and would rise while C remained lying on the ground. A and B, the more active members of the group, were somewhat less active than either the two chicks in group 2/0, or those in 2/1.

(8) Group 3/1: three chicks with one broody hen.

Three New Hampshire chicks and one White Cornish crossed formed this group. Chick A, at the start of the observation, was
1 1/2 hours old, and weighed 46 grams; B was about 2 hours old and weighed the same; C was also about 2 hours old, and weighed 48 grams.

This group did not exhibit the same division between its members as did the previous one. Although the chicks did form themselves into a pair and an individual on many occasions, the members of the pair were not always the same, nor did they oppose the intrusion of the third chick (again, this phrase is used descriptively only), and, indeed, these chicks were often found in a trio.

Their approaches to the hen were similar to those of the chicks in group 2/0, except that two chicks would usually approach her more or less at the same time, while one would stand some 18 inches away. Sometimes one would approach alone, and at other times, all three chicks moved towards her together. Chick B received the greatest number of pecks from the hen, which is related, no doubt, to the fact that it was this chick which approached the hen more often. B approached the hen about 10 times on the first day, and once the second day, while A and C approached her seven times, on the first day only. If two chicks had approached and been attacked by the hen, the third chick would run towards them, whereas, if one chick had approached by itself, it would run to the other two when it had regained balance.

The hen behaved much as the other hens had done, except that, when the observer arrived on the second day, she was sitting much closer to the lamp than the others had been, and closer than she was on the previous evening. She sat about 2 feet from the lamp at this time (the chicks were underneath it) and she settled on this spot whenever she was not moving about on the second day (i.e., she sat here most of the time).

(9) Group 4/0; four chicks with no broody hen.

This group contained four New Hampshire chicks. A was 5 hours old and weighed 49 grams; B was 3 1/2 hours old and weighed 48 grams; C was 3 1/2 hours old and weighed 46 grams, and D was 2 1/2 hours old and weighed 49 grams, at the start of the observation. B was indiscriminable from C, and was identified, therefore, by means of a small piece of white paper, fastened to the middle of its back with adhesive tape. This was done just before the chicks were placed in the observation pen--it did not appear to have any effect upon the chick's behaviour; the chick did not peck at it or preen in that area, which it could easily have done.
The chicks acted more or less as a single group—they did the same things at roughly the same time. They sometimes split into two pairs, but never remained in two groups of 3 and 1 for more than a few seconds—the fourth chick would quickly run (usually) or walk to the others. They showed the mutual preening and pecking as did the other dual and plural groups, as well as the forms of behaviour described in connection with the single chick. Chick B was probably the most active/aggressive/dominant, and Chick D probably the least so (it remained under the lamp somewhat longer than the others on many occasions), but this is the expression of but a mild impression.

This group was the most active of all the groups. The chicks spent only short periods lying beneath the lamp, never more than twenty minutes at a time, and usually less than this, whereas the least active group (the single chick in group 1/0) spent periods of up to an hour or more lying there. In addition to this greater activity, these chicks also ventured to the far walls of the pen more frequently than did any of the others, indeed, this was the only group which went to the farthest corner from the lamp (except when chicks, in other groups, approached the hen in that corner).

(10) Group 4/1: four chicks with one broody hen.

This group contained four White Leghorn chicks in addition to the White Cornish crossed hen. The chicks' statistics, at the start of the observation period were as follows: Chick A was 4 hours old and weighed 47 grams; Chick B was 3 hours old and weighed 48 grams; Chicks C and D were about 1 1/2 hours old and each weighed 46 grams.

These chicks formed into pairs when they stood up, after spending about 10 minutes (until the arrival of the hen) lying under the lamp. They watched the arrival of the hen, moving around occasionally beneath the lamp. As the hen strutted quickly to the far end of the pen, Chick C ran about on one foot, in very jerky fashion, towards her but stayed there while the hen continued another 3 feet or so. Chick D slowly walked towards C, who moved back towards the lamp. C and D stood in area two for several minutes, close together, and looking towards the ground, pecking occasionally, and looking towards the hen. A and B, meanwhile, remained beneath the lamp, looking towards the hen and towards the two chicks ahead, moving around in this area, and occasionally pecking towards the ground.

Thereafter A and B, and C and D formed into two respective pairs during most of the time when they were not lying beneath the lamp (at which time they lay in one bunch). The members of one pair did not, however, peck at the members of the other if the latter approached them, and often all four would move as a single group—but, as in group 4/0, the chicks never
formed into groups of 3 and 1, or never stayed that way for more than a few seconds. In this case, however, the single chick would usually not run to join the three, but rather, one of the others (almost invariably its more constant companion) would run or walk out to join it, and the group would continue as two pairs immediately following this.

A and B, as a pair, approached the hen about twice as often as did C and D. A approached her eight times, B did so ten times, while C and D did so five times each. The latter two chicks watched the former ones whenever they approached the hen, standing about 18 inches from her. On several occasions, three chicks approached, while one remained distant, but only once did all four chicks move in together. Usually, two approached while two stood apart. None of the chicks approached the hen on the second day.

B. IN THE IMPRINTING SITUATION

(1) FIRST EXPOSURES

Chick No. 1, approximate age = 4 hours.

When E raised the lid of S's box, S looked up and around. As E's hand approached, S stood up. As E lifted S off the floor, S gave few loud sharp calls, and struggled with its whole body for a moment--moving backwards, in so doing, towards E's wrist. Settled down in E's hand. E placed his other hand, in cupped fashion, over the hand holding S. S quiet as carried in this fashion to runway. Few loud chirps as S was lifted over the walls of runway and placed on floor (E used only one hand in doing this).

Immediately settled on floor, head medium high, body collapsed on ground, eyes open, and head flicking around slightly--no sound from S for approximately 10 seconds. Then waddles/flutters to the left about 6 inches, with head up and calling loudly. Settles as before, but with head much higher and still calling loudly. After about 1 1/2 minutes flutters/waddles forward, as before, still calling--about 18 inches. Settled for 2 minutes, head flicking/jerking around, occasional shift of body position, quiet. Then flutters forward, as before, and in several directions, calling loudly.

[The calls were timed, approximately, as follows: 4 or 5 calls in 2 seconds; rest, of between 1 1/2 and 3 seconds; then repeated several times. They were not always so regular, however--there would, sometimes be up to 12 calls in rapid succession, with some slower ones towards the end of the burst.]
Settles down near wall, head up, calling loudly. Waddles forward against the wall. About every 10 seconds, waddles/flutters along or near wall (using wings, as it moves, with jerky fluttering action). Calling almost continuously in irregular bursts.

SOUND ON:

No noticeable difference in chick's behaviour. Calling continued as above, with occasional pauses of up to 5 seconds. Stays mostly in same position, body collapsed, feet underneath, head medium high, head often moving around in small jerks, feet/body shifting slightly on occasion. Loud calling continues almost the whole time, sometimes with a few lower-pitched rougher notes, and intensity may vary. Remains near wall (about 1 inch from it) during this time.

MOVEMENT ON:

S watches target-object (T.O.) approaching when T.O. is approximately 18 inches away, stopped calling as it watched. As T.O. passed S, S fluttered forward almost to it, pecked at side of T.O. twice, watched it depart, fluttered forward in same direction for about 8 inches, settled, body down, watched it move another foot or so, then looked around in several directions, calling starts again (had remained quiet since first seeing T.O. until now).

As T.O. approaches again, S runs to it while it is still about one foot away, pecks at it, turns body around with T.O. as it passes, moves with it, then just behind it, for about 3 feet. Stops, watches it depart, then looks around in several directions, head stretched up, body flat on ground, calling loudly until it returns. As soon as S starts to run towards T.O., calling ceases, and does not start again until S stops following and watching T.O.

Subsequent behaviour was very similar to the above throughout the rest of this period (sound on, movement on), with sometimes the following variations:

After it had pecked at T.O., as it was passing, S would occasionally peck at the ground once or twice, then raising head to medium height (beak horizontal), would chobble for a moment. Then it would flutter quickly forward after the T.O. By about 5 minutes of this period, calling had ceased almost entirely, and S would lay head down near or on the floor in front of its body, in the interval between the approaches of the T.O.
It would often peck two or three times at the shavings on the floor, and chobble immediately afterwards. Whenever T.O. approached within about one foot, S's head would come up, and its eyes would open wide (when head was on or near floor, eyes would often be closed, or partly closed). S would flutter towards T.O. (lying in T.O.'s approach line) no more than about 3 inches. As T.O. struck and rolled over S's body, S would usually peck once or twice at it. Following was now much shorter, S usually waddles slowly behind T.O. for about 6 inches, and would then watch it for another 2 feet. At around 8 minutes of this period S looked up at approaching T.O. and ran half the length of the pen to it, chirping softly, turned, followed closely and continuously for 18 inches, then settled down, watched T.O. depart, then head down on floor as well. Thereafter following persists for much longer than before, lasting up to 4 feet as the T.O. departs, and being preceded by S approaching T.O. with a rapid fluttering movement (using wings). There was no occasion on which S did not make some response to the approach of the T.O., even when S's head was on the floor and its eyes apparently closed. At the very least, S would raise head, watch T.O. approach, waddle or flutter towards it a few inches, turn with it, and watch it depart.

SOUND OFF:

No noticeable change in S's behaviour.

MOVEMENT OFF:

S was lying, with head down and eyes closed at the time. Remaind so for 20 seconds, then looked up, head high, stood up, 6 loud calls as it looked around. Ran to T.O. which was swaying from side to side, about 4 feet from chick. Quiet. Pecked twice at T.O., then moved around it, with body touching it, pecking at floor. Moved about 3 inches from T.O., still pecking at floor, settled down on ground, head low, chobbling and further pecking.

Chick No. 2, approximate age = 1 1/2 hours.

Behaviour when being taken from box to runway etc. was comparable to that of the first chick. Immediately settled quietly in runway, head at medium height (beak horizontal).

Remained quiet for 30 seconds, then gives few soft calls, head low but looking around, calls become increasingly loud. Moves after 3 minutes, turning body around, but not progressing. Head moving around most of the time, calls very loud now, bursts of about 8 in 4 seconds, then pause of between 2 and 8 seconds.
Quiet and fairly still in last minute before:

SOUND ON:

Remains quiet, head jerks up when sound comes on, gradually sinks lower again, sinks down to ground within 20 seconds, eyes apparently closed, quiet. Remains thus until:

MOVEMENT ON:

T.O. almost hits S's beak; eyes open, turns head as T.O. passes, turns body, watches T.O. depart. Stretches neck up high, few soft chirps, walks slowly forward (waddles) four paces (T.O. now at end of runway). Body sinks to ground, head medium height, looking slowly around. Watches T.O. approach from 2 feet away, few soft chirps, turns head and body as T.O. passes, watches T.O. depart, waddles 3 paces forward (T.O. 1 foot ahead), pecks, chobbles, few soft chirps, body on ground, head low.

T.O. approaches again, S watches, watches T.O. pass, does not turn head or body to watch it depart. Head sinks down, eyes half closed, jerks head up again before it has sunk to floor, eyes open wide, pecks several times, chobbles, an occasional chirp.

Next time around, S waddles slowly towards approaching T.O., 2 1/2 feet away, turns head and body as it passes, watches it depart. Lies down, chobbles, head very low, few occasional soft chirps.

Next time around, S pays no attention to T.O., but remains with body flat, head low, eyes apparently closed, just outside line of moving T.O. An occasional chobble and chirp.

Thereafter S remained like this for most of the time. It would usually look up as T.O. passed close by it, and would turn head slightly, but quite often it paid no attention to T.O. Head would also come up sometimes when T.O. was not near S, would peck and chobble, and sometimes chirp softly, a few times.

SOUND OFF:

No change in chick's behaviour observed.

MOVEMENT OFF:

Remained lying still, head on ground, eyes closed, for 15 seconds, then jerked head up, eyes open, looked around, gaped
twice, head sank down towards ground again (very slowly), shifted position of legs underneath its body, head sinks onto ground.

**Chick No. 3, approximate age = 5 hours.**

Behaviour, when being transported to runway, was similar to that of the first chick.

When placed in runway, stands, head up, looking around, loud calls within 5 seconds—these continue until the sound comes on (see below). Runs/flutters forward after 1 1/2 minutes (quiet for a few seconds during and after this), stands, looks around, as before. Ran forward again about 6 paces after further 30 seconds (quiet while running and for few seconds afterwards). Stands, head moving around, for about 2 minutes, then runs forwards again (another short quiet period). Stands, head moving around just above the floor, then higher, loud calling continues.

**SOUND ON:**

Stops calling immediately, stands (slightly down on haunches) head still, stretched out short way straight in front of body, beak just below horizontal. Remains thus for rest of this period.

**MOVEMENT ON:**

The T.O. came up from behind, without S seeing it, it hit the side of his body. Gives a very long loud cry and runs quickly to the wall (about 1 foot), using wings, and head and body low. Stands still, watches T.O., few loud calls, but mostly quiet, preens left foot vigourously, pecks at ground three times.

A similar pattern of behaviour was observed on the next two occasions on which T.O. passed near S.

On the fourth time around, S stands with head up, watches T.O. as it approaches, passes, and departs. No calls given. Pecks at ground, head comes back up, looks around in several directions, moves slowly forward a few paces. On the fifth time around, S watches T.O. approach and pass. He runs/flutters towards it when it is 18 inches past him, stops 6 inches behind it, quiet the whole time. Stands there, head turning around jerkily, some soft chirping.

On the sixth occasion, S watches T.O. as it passes him and follows (flutters fairly quickly) for one foot, when it is one foot away.
Next time, S looks and runs towards T.O. when it is still 4 feet away, pecks at it as it passes, turning with it, does not move after it. Moves around in same position, head low, pecks twice at ground, head up, chobbling, quiet.

S pays no attention to T.O. when it next passes near him, is sitting down now, body flat, head low, quiet, facing a side wall.

The next time, S moves in towards it as it passes, and pecks at it, turning with it. Watches it depart for 18 inches, runs forward four paces, stands, looking all around.

The tenth time the T.O. passed, S watched it until it was near the far end of the runway, then ran the whole length of the runway, followed it around the pulley, pecking at it as S followed. Stops, head goes down to ground, pecks several times.

The next time around, S watched approach of T.O., ran towards it for 6 inches when it was one foot away, lies down, head almost on the ground.

Thereafter S remained lying in the same position, quiet, head on the ground. When T.O. passed, S's head would come up, with eyes open, but after about five seconds, head would sink quickly down again. On two consecutive occasions S appeared not to notice the T.O. as it passed.

SOUND OFF:

No change in S's behaviour.

MOVEMENT OFF:

No change in S's behaviour. Head moved slowly up off the ground, eyes still apparently closed, and sank back down again slowly within a few seconds, after about 45 seconds of this condition.

Chick No. 4, approximate age = 4 hours.

Behaviour similar to that of first chick, before being placed in runway.

Stood, head up, looking around, extremely loud calls within 5 seconds, shifts legs several times, hardly moving. Remains like this until:
SOUND ON:

Stops calling, goes down on haunches (body just clear of ground), head pulled into body, beak above horizontal.

MOVEMENT ON:

The T.O. passed him at about 3 inches distance, S appeared not to notice it. He waddled towards centre of runway, with back to T.O., when T.O. was at far end. T.O. rolled over his body, S turned head towards it, gave single, moderately loud chirp, watched it depart.

The next two occasions were similar to this. The fifth time T.O. passed, S watched it pass him, then walked after it for 5 paces, staying very close to it. Then S stood, quiet, pecking, moving around slightly most of the time.

The next time, S was pecking at ground when T.O. came near--S appeared not to see it, continuing to peck. The subsequent passing was the same as this.

Then S looked up at T.O. as it next passed, walked after it for one foot, staying about 6 inches behind it. Stopped, watched it depart, pecked at ground several times, turned, stretched whole body, fluttering wings, pecking again.

When T.O. next approached, S turned with it and watched it depart, then body sank to floor, eyes slowly closing and head slowly dropping towards the ground in front of S's body. Remained so until T.O. was near (2 feet) again, when walked towards it, turned with it, stood watching it depart. Settled on ground again, chobbling as it went down.

Thereafter, S remained with body on the ground for most of the time, with head on or near the ground, and eyes at least partly closed. On every subsequent occasion, except three, when T.O. approached, S's head would come up, and eyes would open for few seconds as it passed, then head would sink back onto ground again, with eyes closing, before T.O. was one foot away. Occasionally S shifted legs slightly under its body.

SOUND OFF:

No change in S's behaviour.

MOVEMENT OFF:

No change for 40 seconds, then S ran quickly forward, away from T.O. (which had been 4 feet away), settled down again, with two soft chirps.
Chick No. 5; approximate age = 3 1/2 hours.

Initial behaviour the same as with the first chick. Squatted (on haunches) in runway, head moving slightly, soft chirps within 5 seconds, lasted 30 seconds. Then quit for 30 seconds. Then short bursts of 6 to 8 moderately loud calls, with interval between bursts of about 15 seconds. This changed to long bursts of louder calls, about 15 calls in each burst, with intervals between the bursts of about 3 seconds.

SOUND ON:

Immediately quiet. Remained in same position, head still, beak horizontal, few soft chirps during the two minutes.

MOVEMENT ON:

The T.O. struck S's body, before S saw it. Ran fluttering away, very loud calls, to side of runway. As it approached again, S ran ahead of it along wall, with loud calls. Stopped at end of runway, watched as T.O. caught up, still calling loudly, ran back along runway when T.O. about 6 inches distance, loud calls as it ran. The same thing happened on the next two occasions when T.O. came near S. Then, as T.O. caught up with S again, S turned back towards it, and stopped calling as it passed.

The next five times T.O. approached, S gave several loud calls as it came near, then was quiet as it passed and departed--S watched it during this time.

For the next two occasions, S remained quiet the whole time, pecking at the ground intermittently, body sank to ground, head sank towards ground, eyes closing at the same time. Paid no attention to T.O.

The time after this, S looked up, watched T.O. pass, stood up, walked behind it for four paces, stood watching it depart, then pecked, turned around, looked in opposite direction, with an occasional soft chirp.

Then the T.O. hit S on the side before S saw it. S turned quickly around, no calling, watched T.O. depart, and walked 7 paces after it. Pecked several times, standing still, then ran towards T.O. as it went around the pulley wheel.

Thereafter S usually stood pecking, looking around with head low, occasionally shifting position. When T.O. approached, S would watch it turn with it, watch it depart for about a foot, then walk 6 paces or so after it, and resume pecking etc. S remained quiet the whole time.
SOUND OFF:

No immediate change in S's behaviour. Then gave a few soft chirps as T.O. departed. After that, S ran behind and past T.O. for about half the length of the runway, stood, pecked at ground. When T.O. had gone farther away, S gave many loud calls, became quiet when it was near. This continued until:

MOVEMENT OFF:

S was just behind T.O. at the time. S stood still, watching T.O., then body collapsed onto ground, head sinking down, eyes closing.

Chick No. 6; approximate age = 6 hours.

Initial behaviour similar to that of first chick. Stood quietly in runway for 5 seconds, then very loud calling, ran to side wall, then along this wall and back, calling loudly the whole time, and moving for most of the time (occasional pauses of about 5 seconds, when S would stand facing wall, head up, and jerking slightly).

SOUND ON:

Stood quietly for 10 seconds, head up, still, then began running again, about 1 inch from the side wall, and across the end walls, about 6 inches from them, calling loudly almost the whole time.

MOVEMENT ON:

No change in behaviour for about 4 minutes, paid no attention to T.O. Sometimes ran in same direction as it, sometimes in opposite direction, sometimes towards it, sometimes away from it, sometimes passed it at the ends of the runway, sometimes in the middle. Loud calls most of the time. Then S suddenly stopped calling as T.O. approached, watched it pass him, then started calling loudly again when it was 2 feet past him. The same thing happened the next time around. The following time, however, S ran after T.O. for 2 complete circuits, almost without pausing. S would run up to T.O., and place the side of his head against it. S would then stand and watch T.O. until it was about 1 foot ahead again, when he would repeat this procedure. S occasionally pecked at the ground in between the runs to T.O. S called loudly, but less often then before, during all this time, both when running and when standing watching T.O.

After this S stood in one corner of the runway, looking towards the walls, calling loudly, paying no attention to the T.O.
When it had passed him several times, S turned, as it passed again, watched it, then ran after it for 2 feet, calling loudly, and stopping about 6 inches in front of it. When T.O. passed him again, S ran up to and in front of it again, still calling most of the time. Then S watched T.O. depart.

SOUND OFF:

S stood quietly for 15 seconds, watched T.O. pass, ran across to wall, calling loudly. Ran along the wall, still calling. Stopped and watched T.O. several times, when it was moving near him, but did not follow it. Was quiet at these times, then resumed calling and running around the walls.

MOVEMENT OFF:

Continued loud calls as ran around walls. Paid no attention to T.O. which was swaying near one corner; passed close to it several times.

Chick No. 7; approximate age = 3 hours.

Initial behaviour similar to that of first chick.

Squats on haunches in runway, quiet for about 5 seconds, then begins calling loudly and almost continuously. Stays thus until:

SOUND ON:

Stays squatting as before, calling stops for 10 seconds, then intermittent short bursts of loud calls until:

MOVEMENT ON:

As T.O. approached, S watched it. When T.O. was 2 feet away, S started calling loudly. As it passed him, S became quiet, turned with it, watched it depart. Remained quiet. Settled down, body flat, head low and almost still, eyes open.

On each of the next three occasions, the T.O. rolled over the top of S's body. S remained quiet both before and after T.O. passed, and did not look up at it.

The next time around, S watched approaching T.O., and turned head and body (slightly) as it passed, then turned head right around the other way, past the front of its body, and watched T.O. depart.
Next time, S looked up as T.O. passed, and watched it depart. This happened on the two subsequent occasions also.

Then, when T.O. was at far end of runway, S gave several loud calls. As it approached to within 3 feet of him, S became quiet, watched it pass and depart, turning both head and body.

S then moved across to a side wall (the first time S has moved forward), pecked several times at the ground, squats on haunches, facing wall, occasional soft chirp. Does not respond to T.O. the next three times it passed near him. Then turns towards it as it approaches, watches it pass and depart. Head sinks down to ground, body flat on ground, eyes half closed. Pays no further attention to T.O.

SOUND OFF:

Remains quiet and in same position, but head comes up, turns in several directions. As T.O. passes him, S watches it turning only his head, except on two occasions when he turned his body as well.

MOVEMENT OFF:

Remains quiet for 10 seconds, then extremely loud calls, runs across to opposite wall, stands, quiet for 15 seconds, calls loudly again, head high, looking around. Runs along side wall for 4 feet, calling loudly. Lies down about 2 inches from swaying T.O., head near ground, eyes half closed, quiet.

Chick No. 8; approximate age = 5 hours.

Initial behaviour similar to that of first chick. Squats quietly in runway for about 5 seconds, then soft calling, becoming louder. Stands up after 30 seconds, very loud calling. Runs in short burst around most of runway, calling loudly. This continues until:

SOUND ON:

No change apparent. The pauses in S's running, and in his calling, do not coincide.

MOVEMENT ON:

The first six times T.O. passed near S, he appeared not to notice it—his behaviour continued with no change from the above manner. On the seventh, eighth, ninth, and thirteenth
occasions that the T.O. passed him, S turned head and watched it (standing still). Apart from that his behaviour remained unchanged—as he watched the T.O., S continued calling loudly.

As the T.O. passed him for the fifteenth time, S pecked at it twice, then stood and pecked at the ground, without calling. Squatted on haunches for about 15 seconds, then stood up, began calling loudly again, and resumed his running in short bursts. This continued until the T.O. stopped moving (see below).

SOUND OFF:

No change.

MOVEMENT OFF:

Still calling loudly and running about. Runs to T.O. (swaying at one end), pressed side of head, neck, and breast against it, then pecked at it three times. Quiet as soon as he reached T.O. Pecks at it several times more, as it sways in front of him. Presses body towards T.O., does not move as it strikes him. After 50 seconds, runs to the other end of the pen, stands there quietly, looking at wall.

Chick No. 9: approximate age = 4 1/2 hours

Initial behaviour similar to that of the first chick. When placed in runway, squatted on haunches, body just off the ground. Quiet for few seconds, then soft calling, becoming quickly much louder. Remains thus for most of the time, with an occasional run (6 in the five-minute period) forwards about one foot, when squats again. Loud calls continue both when S moving and still.

SOUND ON:

No change—S runs forward, about one foot, three more times in this period.

MOVEMENT ON:

As the T.O. approached for the first time, S ran towards it. It hit him as it passed. As he ran to it S was quiet, and he remained so as he turned and watched it depart.

Loud calling resumed when T.O. was about three feet past S. He ran about near one side wall in the middle of the runway, ignoring the approaching T.O. This continued on four more occasions. As the T.O. passed S, after this, it struck his body. S turned and watched it depart, calling ceased. He then
ran after it when it was 2 feet away, stopped in front of it, watched it pass again, ran after it again. Few soft chirps in this time. Loud chirps as T.O. moved to other end of runway, quiet as it returned (S ran towards it).

For the rest of this period, S usually watched the T.O. as it approached him, about 2 to 3 feet ahead of him, then turned as it passed, and watched it depart for about 2 feet, when he would run either up to it, or just behind it, stop and watch it pass him again, and then run up to it again. During this time, S was mostly quiet, with an occasional soft chirp or two.

SOUND OFF:

Behaviour as before.

MOVEMENT OFF:

S was 3 1/2 feet away from T.O. at the time; S stood, head up, quiet, looking around. Then started calling loudly after 10 seconds, ran across runway away from T.O. Stands, calling loudly, head turning in several directions, including towards the T.O., some six feet away.

Chick No. 10; approximate age = 3 hours.

Initial behaviour similar to that of the first chick. Squats in runway, quiet for 35 seconds, then stands up, softly calling, then more loudly. Short bursts of running around runway for about one foot, then long pause (squatting) until next burst. Calling loudly almost continuously.

SOUND ON:

No change in S's behaviour.

MOVEMENT ON:

As T.O. passed S, it struck his beak. S gave a sharp loud chirp, shook his head, and stood still. Stood in same spot, calling loudly, until T.O. approached again—just before it passed him, S began pecking at the ground. The T.O. passed over S's lowered head—S made no apparent response to it, but continued pecking, with bursts of loud calling between most pecks.

The third time T.O. approached, S looked towards it, and turned his head (not his body) as it passed. He was still calling loudly.
As T.O. approached next time, S stopped calling, moved towards it (6 inches away), turned his head and body, and watched it depart.

The next time, S ran towards T.O., one foot away, turned and pecked at it as it passed.

On the sixth occasion, S watched it pass him, then ran after it for one foot, when it was 2 feet away. He then watched it depart again, and preened behind his left wing.

The next time around, S ran after it, looking away to the side, in the direction of one wall. Stopped just behind T.O., pecked at ground several times, and gave a few soft chirps.

On the next two occasions, S was pecking at the ground, walking about slightly, with head low--he paid no attention to the T.O.

The tenth time it passed, S ran towards it (2 feet away), turned with it, and watched it depart. He ran after it when it was one foot away. Stopped on reaching it, pecked at the ground, ran after it when it had moved a farther 2 feet, and stopped six inches behind it. Stood looking all around, still quiet.

The next time, S ran to the T.O. (2 1/2 feet away) pecked at it, did not turn and follow. Pecked at the ground several times.

S was looking towards the wall when the T.O. next passed--he made no response. As he stood in this position, S gave a few soft chirps.

Then S ran to the approaching T.O. (1 foot away), pecked at it as he turned with it, and watched it depart. Pecked at the ground.

After this, S ran to it when it was 2 feet away, then stood, pecking at the ground. Few soft chirps. S did not turn and follow.

Thereafter, S ran to the T.O. when it was about 2 feet away, turned with it (sometimes pecking at it), watched it depart, then stood looking around, or pecking at the ground, moving his feet slightly, and remaining quiet.

SOUND OFF:

When T.O. next approached S, he ran to it (1 foot away), turned with it, watched it depart for one foot then ran after it,
and followed it steadily for about 4 feet, some 10 inches behind it. Then $S$ stood still, head moving all around, pecked at the ground for the rest of this period, paying no further attention to the T.O., but moving around, with head low.

**MOVEMENT OFF:**

$S$ stood watching swaying T.O., about $3 \frac{1}{2}$ feet from it. After 10 seconds $S$ ran to it, stood pecking at it, then walked slowly and jerkily around it, and pecked at the ground several times. $S$ then pecked at T.O. several times more, then at the ground again.

**Chick No. 11; approximate age = 6 hours.**

Initial behaviour similar to that of the first chick. In the runway, $S$ stood still and quiet for 15 seconds, with head at medium height (beak horizontal and pointing directly forward). Then $S$ moved forward 3 paces, and gave a few soft chirps. The chirping became louder and much more frequent. $S$ moved around on the same spot, head moving all around (including up and down) continuously.

**SOUND ON:**

Quiet for 10 seconds, then loud calling and looking around, as before.

**MOVEMENT ON:**

As soon as T.O. approached, $S$ stopped calling, and did not call again during the whole session. $S$ watched T.O. approach, pass, and depart, turning his body as T.O. passed. $S$ watched T.O. as it moved all the way down to the end of the runway and back again. $S$ pecked T.O. as it passed for the second time, turning with it, then pecked at ground and chobbled.

Subsequent behaviour in this period was similar to that above: whenever T.O. approached, $S$ looked towards it, usually turning with it and watching it depart. When it had passed, he pecked at the ground, moving about in the same area, with head low. Occasionally $S$ would peck at the T.O. as it passed. He raised his left foot towards his beak on one occasion (T.O. at far end) and pecked at it, almost losing balance. $S$ did not move from the immediate area until:

**SOUND OFF:**

T.O. approached, $S$ turned with it and followed it around a complete circuit, staying within 6 inches of it, and
behind it all the way. Then $S$ pecked at the ground until $T.O.$ approached again, when he followed it for one length of the runway. Then he stood looking about, or moving around, pecking, paying no further attention to $T.O.$ until:

**MOVEMENT OFF:**

$S$ stood watching $T.O.$ for 5 seconds, as it swayed. Then ran up to it, pecked at it, pecked underneath it, and at the ground, around it. He moved around the $T.O.$, pecking in this fashion.

**Chick No. 12; approximate age = 3 hours.**

Initial behaviour similar to that of first chick.

In the runway $S$ lay with body on the ground, head at medium height, looking around—quiet for approximately 10 seconds, then a few soft chirps. These became much louder within a few seconds. $S$ stands up, head high, calling loudly after 1/2 minute. One and a half minutes later it lies down again, stops calling, head at medium height, looking all around. Remains thus until:

**SOUND ON:**

No change.

**MOVEMENT ON:**

No change until $T.O.$ is within 6 inches of $S$, who pushes head down beneath it as it is about to hit its head. Turns head and watches as it goes past and departs, then turns head towards wall, sits like this, still and quiet until $T.O.$ approaches again, when $S$ turns and watches it approaching, passing, and departing, gives a few soft chirps as it nears him. Pecks at the ground, stands up, head low, pecking at ground, moving around slightly in the immediate area.

This type of behaviour continued during the rest of this period. For most of the time, the chick moved slowly around a small area near the middle of the runway, pecking at the ground, and looking downwards. On a few occasions it gaped, raising its head as it did so, and it would occasionally give a few soft chirps. After about five minutes, it stretched its whole body, fluttering its wings, and almost losing balance as it did so. Whenever the $T.O.$ came close (except on two occasions), $S$ turned its head and body, and watched it, then resumed its pecking etc.

**SOUND OFF:**

No change observed.
MOVEMENT OFF:

Stood still, head high, looking about, then resumed pecking after about 15 seconds. After further 25 seconds, begins calling loudly, head comes up very high, looking all around, approximately 3 feet from the T.O.

Chick No. 13; approximate age = 5 1/2 hours.

Initial behaviour similar to that of first chick. In the runway, it squats on its haunches, body just off the ground, for about 5 seconds, then stands, head high, calling loudly, looking straight forward for most of the time. After 3 minutes, calling almost ceases, now being less loud and much less frequent, still standing, head medium height.

SOUND ON:

Remains as above, for 15 seconds, then begins calling loudly and continuously, head held high.

MOVEMENT ON:

As T.O. approaches (6 inches away), S stops calling, turns, watches T.O. as it passes and departs. Then calls again, when T.O. is 1 foot away, and moves around a small area.

As the T.O. approaches again, S jumps back out of its path, and immediately jumps forward again, pushing breast at it, with wings slightly raised. Calling ceased during this time, resumed again as T.O. departs (1 foot away).

The third time around, S pays no attention to the T.O., and this happens for the next three times, S moving around, calling.

On the seventh occasion, S watches it approach, jumps forward at it as it passes, lunges head forward, but does not appear to peck it. During this time, S is quiet, calling is resumed when T.O. is about 2 feet past.

The next time, S watches it approach, calling ceases, pecks three times at it as it passes, moving forward two paces as it pecks, and turning with it, then moves around, looks around, calling again when T.O. about 18 inches away.

S is running along one wall as T.O. passes the next time, calling loudly, and paying no attention to the T.O.
On the subsequent occasion, S is moving around a small area, two-thirds of the way along the runway, with head high, looking around, and calling loudly—it does not appear to respond to the T.O.

Thereafter, S continues calling loudly, as it moves around a small area (radius of about one foot), with head high, and looking around in several directions. Whenever the T.O. is close, S watches it briefly and quietly, then resumes calling etc.

SOUND OFF:
No change observed.

MOVEMENT OFF:
No change observed—S paid no attention to the swaying T.O.

Chick No. 14; approximate age = 3 hours.

This is the first of the second group of subjects, to whom the larger T.O. was presented.

S behaved initially in a fashion similar to the first chick's. In the runway, it lay on the ground, head at medium height, looking around, began calling softly after 10 seconds, then more loudly. Stood up, stretched whole body, fluttering its wings as it did so, moved few paces forward, head high, calling loudly. Head jerking in several directions. Continued in this manner, occasionally moving forward a few paces, until:

SOUND ON:
Quiet as soon as sound starts. Stands still, head at medium height, looking straight ahead. Moves head only for rest of this period, remains quiet.

MOVEMENT ON:
As T.O. approaches, S pushes head forward, giving two soft chirps, and turning as T.O. passes. Chirps become much louder and continue as T.O. passes to the end and returns. When T.O. is within 1 foot again, the calls cease, and S turns his head towards T.O., which strikes the side of his body. S gives a loud cry, shifts his position, shakes himself, turns and watches departing T.O., waddles forward, fluttering wings—appears to have great difficulty in moving through the shavings on the floor. Stops after 6 inches, lies down, head up, several loud calls, burst of pecking into shavings. Head comes up, quiet for a few seconds, then more loud calls. T.O. is now
approaching once more. S is quiet as it comes to within 1 foot of him, flutters/waddles towards it, swings around after they pass, moves forward after T.O., topples to one side, few soft chirps, head comes up.

As T.O. approaches again, S gives a few soft chirps, flutters/waddles to it as it approaches, follows it at a foot's distance for about 18 inches. Falls to floor, stands up, calling loudly; this calling continues until T.O. approaches again, when S is quiet, and watches the T.O. move past him--does not approach it but lies down as it departs, head sinking down, and eyes closing. Pecks at the shavings, turns, waddles 4 inches to the wall, lies, with head up, facing wall--very still. As the T.O. passes, S gives no response, turns around a few seconds later, pecks at the ground, gives a few soft chirps, runs to the T.O., about 3 feet away, stops 6 inches behind, and follows it for 2 feet. Lies down quietly, head low and facing downwards, quiet, with head sinking to the ground, eyes closing.

Thereafter continues lying like this--head comes up occasionally, and eyes half--or fully--open, but head quickly sinks down again. Paid little further attention to the T.O., would occasionally watch it briefly, turning head with it, but most of the time S did not appear to notice it.

SOUND OFF:

No change in S's behaviour.

MOVEMENT OFF:

No change observed.

Chick No. 15; approximate age = 4 hours.

Initial behaviour similar to that of the first chick. Squats on haunches in runway, body just off ground, head at medium height and jerking around, from side to side. Quiet for 15 seconds, then soft chirping, quickly becoming louder. Head now higher, looking straight forward for most of the time.

SOUND ON:

S stops calling for about 20 seconds, pecks twice at the ground, then head comes back up, looks around, calling loudly again.

MOVEMENT ON:

The T.O. hits S before he sees it, he chirps loudly, and rolls to one side, regains balance, body flat on ground, turns head and watches departing T.O., calls loudly.
The next time around, S watches T.O. approach, and pecks at it twice as it passes, standing up as he does so. Runs forward up to it, when it is one foot ahead, stands quietly, watching T.O. depart.

On the next occasion, S watches T.O. approach, pecks at it as it passes, and moves with it for about six inches. Squats on the ground, head up, looking all around.

As the T.O. passes next time, it rolls over S's body. He chirps loudly, turns head towards it, pecks at it, and watches it depart.

On the next six occasions, the T.O. passes very close to S's body, without touching it--he turns his head as it approaches, pecks once or twice at it, and watches it depart.

On the next three occasions, S gives a few soft chirps as T.O. approaches, stands up, turns head and body with it, pecks at it as it strikes and moves around his body--he does not move out of its path.

After this S lies down, with his eyes closed, (the T.O. is at the other end of the runway). As T.O. approaches, it touches the top of his head; S chirps, raises head, waddles slowly after it for short distance (about 6 inches), and watches it depart, then settles back down again, eyes closing. The same pattern of behaviour is seen on the next occasion.

S is now out of the path of the T.O.; he remains lying down with eyes closed, as the T.O. passes on the next two occasions.

Then, his head comes up as T.O. approaches, he chirps softly several times, watches it pass and depart, then settles down again, head slowly sinking towards the floor, and eyes closing.

After this he does not respond to the T.O. for the next three occasions, but remains with head and body on the ground, and eyes closed.

SOUND OFF:

S looks up, eyes open, head moves around to the right, then forwards, and to the left. Stands up as T.O. approaches, chirps softly and watches it pass, turning his head and body, and walks slowly forward three paces. Watches it depart, then looks all around.
Thereafter, S runs forward a short distance to the approaching T.O., turns as it passes, and either watches it depart, or watches and follows it for about one foot.

MOVEMENT OFF:

S was watching T.O. at the time, having just been following it for one foot. He walked up to it as it was swaying, chirped softly several times, moved around it, and stood, with his back to it, head medium high, looking towards a corner (nearby) of the runway.

Chick No. 16; approximate age = 5 hours.

Initial behaviour similar to that of the first chick. Stands in runway, looking all around. Loud calling after half a minute, head held high. Moves feet slightly, turning slowly around.

SOUND ON:

Stands still and quiet for 15 seconds, then resumes loud calling, head held high.

MOVEMENT ON:

The T.O. hits him before he sees it, he chirps quietly, turns, and walks quickly after it, quietly, for 3 feet. Stops, watches it pass around pulley wheel, runs to it as it approaches again, turns with it, follows steadily for 4 feet. Stands still and quiet, head moving around near ground.

The T.O. hits him again as it passes, he chirps, moves quickly out of its path, watches it depart, then looks in several directions. Runs to T.O. as it approaches again (3 feet away), turns with it, chirping softly, moves quickly after it for one foot, as it departs.

Thereafter it pecks at the ground, chirps, preens (once or twice), and moves around in small area, when the T.O. is distant. When it approaches, S moves towards it, turns, watches, and (usually) follows for 6 inches to one foot. S chirps softly both when the T.O. is near and when it is more distant--its chirps are louder and more frequent when the T.O. is within one foot (either way) of it.

SOUND OFF:

S was pecking at the ground at the time, it looked up, stood still and quiet for 15 seconds, until T.O. passed it, when
S pecked at it, watched it, and fluttered quickly after it for one foot. Stood pecking at the ground, and moving head around just off the ground. Behaviour towards approaching T.O. continued as above.

MOVEMENT OFF:

S continued looking around the ground, pecking, and softly and intermittently chirping. It was 3 feet from the swaying T.O.

Chick No. 17; approximate age = 3 1/2 hours.

Initial behaviour similar to that of the first chick. In runway, body flat on ground, head fairly high, head moving around, quiet for 30 seconds, then soft calls quickly becoming louder. Stands up, moves forward a few paces, head up high, calling loudly, moving slightly forward most of the time. Continues until: "SOUND ON:

Stops calling, stands still, head thrust forward, quiet. After 15 seconds lowers self to ground, looks around near ground, pecks several times, remains quite still for 30 seconds, then preens at bottom of breast.

MOVEMENT ON:

Remains quiet as T.O. approaches, turns head and watches when T.O. 3 feet away. Does not watch T.O. depart, some loud calling (T.O. just past pulley wheel at far end), head up high, looking in several directions.

As T.O. approaches (2 1/2 feet), S turns, watches, waddles forward a few paces, and moves behind T.O. for about 6 inches, chirps softly four times. Settles back on ground, body flat, head sinks slowly down, jerks up, goes slowly down again, eyes closing--head jerks up again, looks around, pecks at ground, long burst of soft chirps. Looks up as T.O. approaches, chirps continue, watches T.O. until it passes him, then looks back down towards ground, head sinks down, eyes closing; head comes up again, eyes open, waddles forward and to the right, settles down near wall, facing middle of runway, almost.

Thereafter S would respond to approaching T.O. about every second time it passed, by looking up, standing almost upright, walking jerkily towards the middle of the runway, and after the departing T.O., about one foot, chirping softly and intermittently. It would then lie down again near the path of
the T.O., head going down to ground fairly quickly, and eyes closing. Head would either rest on the ground, or just above it. On about half the occasions when T.O. passed, S would make no response.

Towards the end of this period, S responded even less than this, and appeared to be "asleep" for much of the time.

**SOUND OFF:**

No change from the last-mentioned behaviour.

**MOVEMENT OFF:**

No change—the T.O. was about five feet from S, at the far end of the runway, and S had his back towards it.

Chick No. 18; approximate age = 2 1/2 hours.

Initial behaviour similar to the first chick's. In runway, S lay on ground, head at medium height, looking around. Quiet for 20 seconds, then soft calls, which became slightly louder, but were not as loud as those of most other chicks. Frequent pauses, when chick was quiet. Did not stand up, or shift position until:

**SOUND ON:**

This occurred in the middle of a quiet period. S remained quiet, looking about him, head up high, stood up after 15 seconds, stretched whole body, fluttering wings, walked jerkily forward about 6 paces, head down towards ground. Stood with head moving near ground for rest of this period, quiet, shifting feet slightly.

**MOVEMENT ON:**

The T.O. rolled over his back before he saw it, S chirped loudly, rolls body sideways, stands up, looking around, and then looks towards ground, few soft chirps.

As T.O. approaches again, S still chirping softly, head comes up, watches T.O. as it passes near him, runs, with some difficulty after it, for about one foot, pecks at it, then stands watching it for about 3 feet more. Settles down on ground, head goes down to ground, pecks slowly several times, quiet.

Thereafter S would look up as T.O. came within 1 foot of him, turn his body around with T.O. as it passed, and (usually)
waddle no more than one foot after it. Occasional soft chirping, but mostly quiet.

After 5 minutes of this, S did not respond as T.O. passed him four times.

When T.O. was not close to him, S would have his head down on the floor, for most of the time, eyes closed, or would have head just off the floor, pecking—often pecked just after T.O. had passed.

S was nearer one of T.O.'s paths, than the other, and he would respond when T.O. passed along this side more often than he would when it passed on other side. His waddling was almost a series of short jumps—appeared to have difficulty with the small piles of wood shavings.

SOUND OFF:

No change in S's behaviour, responded, as above, twice.

MOVEMENT OFF:

S watched the swaying T.O., lying on the ground, head well forward of his body, for 15-20 seconds, then stood up, gave few soft chirps, and clumsily ran over to T.O., pecked at it twice, then settled on the ground, head at medium height, intermittent soft chirps.

Chick No. 19: approximate age = 4 hours.

Initial behaviour similar to that of the first chick. In runway, S stands almost upright, legs slightly bent, looks all around, then down at the ground. Begins calling loudly after 45 seconds. Moves around small area, still calling loudly.

SOUND ON:

No change in S's behaviour.

MOVEMENT ON:

Turns head towards T.O. as it comes within 2 feet of S, turns body as it passes, quiet now, follows for 6 inches watches it depart for 4 feet, then looks all around, quiet.

As it approaches next time, S walks towards it, when it is still 2 1/2 feet away, pecks at it several times, follows for about 6 inches, then watches for 2 feet, and then looks across to wall, then down at the ground. Few soft chirps, moves forwards
slightly. Squats on ground facing away from T.O. as it approaches again, head low, and moving around just above ground. Pecks at ground several times. Stands up, moves towards wall, no response to T.O. as it passed again. Did not respond on next five occasions, but moved around near wall, facing wall mostly, some pecking at ground.

Then turned and ran towards T.O. When it was 3 1/2 feet away, pecked at it twice, turned after it had passed, and walked 6 inches towards it, then looked around, occasionally pecking and softly chirping.

Thereafter S approached the T.O., and turned with it, but did not follow, nor did he watch it for more than 2-3 seconds as it departed. During the rest of the time, S moved slowly around near the middle of the runway, head moving all around, mostly near the ground, occasional peck at ground, quiet.

SOUND OFF:

S looked up at the T.O. as it passed, few fairly loud chirps, then ran after it and stayed with it for just under 4 feet. Stood watching it as it passed around pulley wheel, then ran to it, and followed it for one foot, then turned towards wall, pecking few soft chirps, head moving around near ground. As T.O. approached on next two occasions, S looked up, ran in towards it, followed for about 6 inches, watched it depart for one foot more, then stood looking about.

MOVEMENT OFF:

S continued moving head around near ground, quiet for 20 seconds, then head came up high, loud calls, moved quickly around and towards side of runway. T.O. was approximately 3 feet from him.

Chick No. 20; approximate age = 3 1/2 hours.

Initial behaviour similar to that of first chick; as E was carrying him towards runway, S pushed backwards out of E's hands, and fell to the floor. Immediately stood up, calling very loudly. As E put his hands towards him, S ran behind one leg of the table on which the runway stood, and it was with some difficulty that E picked him up again. S called loudly all this time, until back in E's hands.

When placed in runway, S ran about in middle of it, calling loudly, wings out slightly from body, head high. This continued, with short breaks in both vocalization and running (these did not always coincide), until:
SOUND ON:

Chick stopped running, stopped calling, stood with head high, and straight in front of body, for half a minute, then began calling again, somewhat less loudly. Stayed in same position, head moving around, calling (with short breaks) until:

MOVEMENT ON:

As T.O. approaches S, he stops calling, pecks at it as it passes, turning body with it, few soft chirps as he follows it slowly for 6 inches, then stands, looking upwards, calling loudly, until it approaches again, when S turns towards it, walks towards it (3 feet away), pecks at it twice, turning with it, follows for 6 inches. Watches it move to end of runway, then squats on haunches, body just off the ground, head moving around near the ground, with an occasional peck at the ground. S does not respond to the approaching T.O. on the next four occasions, then stands upright, runs towards it as it approaches (3 1/2 feet), pecks at it three times, turns, walks after it for one foot, stands pecking at ground, moving to left slightly.

For the next six times, S watches T.O. as it approaches, runs towards it for about one foot, turns with it, does not follow, but moves slowly about a small area, head turning all about, some pecking, quiet.

Then S runs to it (1 foot away), turns, pecks it once, follows for over 4 feet, watches it pass around pulley wheel, runs to it again, turns, and follows for one foot. Thereafter, moves around, head low, some pecking at ground, occasional soft chirping. When the T.O. approaches, S watches it, then runs towards it, turns, but does not follow.

SOUND OFF:

Behaviour as above for one minute, then S lies down near middle of runway, facing wall, head sinks downwards, pecks lightly at ground once, head goes onto ground, eyes close. Does not respond to T.O.

MOVEMENT OFF:

S remains lying on the floor in this fashion. Head comes up fairly quickly once, eyes open, but goes back down again, eyes closed, within 5 seconds.

Chick No. 21; approximate age = 3 1/2 hours.

Initial behaviour similar to that of the first chick. In runway, S lies on ground, head at medium height, beak horizontal.
Head fairly still, quiet for 20 seconds, then soft chirping, head moving about more, chirping becomes much louder within a few seconds. S raises self up on haunches, legs well bent under body. Remains thus for rest of this period.

SOUND ON:

Chick stops calling within 2-3 seconds, holds head still, looking straight forward. After 10 seconds gives a few soft chirps, stands up, walks slowly forward about six paces, looks towards one wall, moves towards it, few louder calls, pecks at ground near wall. Stays moving slowly around, and looking all around, in this area.

MOVEMENT ON:

No change in S's behaviour, does not appear to notice T.O. for the first 8 times it passes him, facing wall most of the time. Moves to middle of runway (T.O. at one end), settles down, body flat, head low, head moving near the ground. T.O. comes up from behind S, and rolls over his body. S gives loud chirp, and shuffles quickly to left, looks up at it very briefly, then settles down again, head low, eyes half closed.

On the next four occasions, S looked up as it approached (1 foot), and shuffled awkwardly towards it as it passed. Watched it as it went for no more than one foot, then head sank down again, eyes half closed.

On the next occasion, S shuffled in towards it as it came close, chirped softly 3 times, pecked at it twice, turned body as it passed, shuffled after it for about 6 inches, then settled down again, head moving low near the floor.

Following this, S, (who had settled in one path of the T.O.) was struck by it as it passed. He made no noise, raised his head and watched it briefly, then head went down onto ground, eyes closing.

The same thing happened on the next occasion, except that S chirped softly twice, and pecked twice at the T.O. as it went by his head. S then shuffled slightly to one side and forwards a few inches.

Before T.O. returned, S stood up, head moving all around, stretched left foot behind him, called fairly loudly about 18 times, while moving across and in the area of one wall. Sets down there, does not respond to the T.O. as it approaches, during the rest of this period, head sinks to ground, eyes close.
SOUND OFF:

No change in chick's behaviour. Looks up briefly once, head goes down again within 5 seconds; T.O. was at far end of runway, behind him, at this time.

MOVEMENT OFF:

S remained lying in same place.

Chick No. 22; approximate age = 3 hours.

Initial behaviour similar to that of the first chick. In runway, stood, looking around, moved forward one foot, then to right, few soft chirps, stood still for about half a minute, then walked back to where he had been placed, turned slowly around, few soft chirps. Head goes down towards ground, looks around near ground. Remains thus, with slight movement, and an occasional burst of soft chirping, until:

SOUND ON:

Looks up, head quite still, stays like this for about 20 seconds, then head goes down near ground again, moves slowly around, as before, quiet the whole time.

MOVEMENT ON:

As T.O. approached for the first time, S turned towards it, and waddles (on haunches) towards it, remained quiet, turned as it passed, and watched it depart. Sank onto haunches again, waddles forwards a few inches, looking towards ground, head stretched down in front of him.

The chick behaved in a similar fashion on the next two occasions, then, as T.O. was passing again, he pecked at it once, turned and watched it depart. S then settled down, body flat, on ground, head just off the ground, and still, eyes half closed. He did not react to the approaching T.O.

The next time around, S looked up as T.O. was approaching, shuffled towards it, using his wings, pecked at it, turned with it, and watched it go.

This happened again on the next occasion, but the chick also followed it slowly for about one foot, shuffling forward, on haunches, in a very clumsy manner. He then settled down again, head on ground, eyes closed.
As the T.O. approached, he looked up, watched it pass, shuffled forwards 6 inches, chirping softly. This continued on the next five occasions, then the chick, who had settled down again, did not respond to the approaching T.O.

Thereafter, it looked up at the T.O. (1 foot away) turned its head and body, as T.O. passed, and watched it depart. It did not follow, until the last time, in this period that T.O. approached, when it looked up as T.O. approached, turned as it passed, and walked quickly behind it for about 2 feet.

SOUND OFF:

S stopped following, looked straight ahead, standing still, few soft chirps, watched T.O. as it rounded the pulley, ran over to it, pecked at it once, turned towards wall, looked all around, few fairly loud chirps, pecked at the ground twice, settled down, body flat on ground, head up and looking around. As T.O. approached again, it looked towards it, but did not get up. Quiet. Looked towards it, without getting up, the next two times it did not turn towards T.O., but held its head low near the ground, looking around.

MOVEMENT OFF:

S's head slowly sank onto the ground, eyes closed. After 10 seconds it jerked its head up, stood up, walked forwards 6 paces, settled down again, no calling.

Chick No. 23; approximate age = 6 hours.

Initial behaviour similar to that of first chick. When placed in runway, S stood, quietly, with head high, looking all around. It moved quickly forward, after 10 seconds, calling loudly. Ran in several directions, after this, head moving all around, and calling loudly almost continually. Short bursts of running, covering between one and two feet each time, with pauses of about five seconds between them.

SOUND ON:

Chick looked up, head still, quiet, for 10 seconds, then continued as before.

MOVEMENT ON:

The first time T.O. approached S, he looked towards it, turned head and body as it passed, quiet during this time, then resumed previous behaviour.
On the second occasion, S turned head and body towards T.O., quiet as soon as he attended to it, then few soft chirps as it passed. Remained quiet (few soft chirps). Looked all around, head at medium height, moving about a little.

On third occasion, S turned as before, but also followed closely for 3 feet, around the pulley wheel, then pauses, watches, then runs up to it (1/2 way along runway), follows for another 2 feet, quiet, then watches it depart. Few soft chirps, then quiet, then chirps again as T.O. comes back, turns as it passes him, follows for 2 feet, pecking at it, running up to and in front of it. This continues, almost continuously, for 2 1/2 circuits, usually letting T.O. get about 3 feet in front of him, then running up to it and pecking at it, but also these are occasions when he follows about 4 inches behind T.O., keeping steadily up with it, sometimes pecking at the ground as he follows like this.

Stops at one end, watches T.O. depart, runs to it about 1/2 way down the pen, as it approaches, follows it around pulley at same end. Calls loudly when it moves 5 feet ahead of him, quiet when it returns (about 4 feet away).

Follows, sprinting up to it, then stopping while it progresses about 3 feet; this goes on for one complete circuit. A sudden loud noise outside--heavy footsteps after door closes loudly--S stops, stands still, head up, looking all around, head cocked on one side, quiet.

Continues bursts of following, with pauses in which it watches T.O. for one to two feet, as it runs up to T.O., it usually pecks at it at least once. This, again, is interspersed with regular, steady following, about 4 inches behind T.O. Such behaviour continues until the end of this period.

This chick was the strongest follower of them all.

SOUND OFF:

No change. Occasional peck at the ground in pauses between bursts of following.

MOVEMENT OFF:

S was about 6 inches behind T.O. at the time, and following it. S moved quickly up to it, pecked at it twice, then moved slowly around it one and a half times, looking straight ahead mostly. Then stood, head down towards the ground, right side towards swaying T.O.
Chick No. 24; approximate age = 4 hours.

Initial behaviour similar to that of the first chick. Inside runway, squats on haunches, body just clear of the ground, looks all around, head medium height. Quiet for 15 seconds, then soft chirps, quickly becoming louder. Stands up after 1 1/2 minutes, calling loudly, head high, moves around a little, in same area. This continues until:

SOUND ON:

Chick immediately quiet, stands still, with head forward, medium height. Walks forward few paces, head goes down near the ground, moves around in this fashion, quiet.

MOVEMENT ON:

S turns towards T.O. as it approaches, chirps loudly as it brushes against his body, watches it depart, then stands looking all about, quiet. As T.O. rounds pulley wheel, S gives a few moderately loud calls, and squats on his haunches, head straight in front of body.

As it approaches again, S looks up, turns as it passes, and watches it depart. Chirps several times fairly loudly, waddles/shuffles after it about 6 inches, pauses, watching it, then runs quickly up to it, fluttering wings. Watches it as it rounds end of runway, then runs across to it, pecks twice, then settles on the ground, back towards pulley-system, head fairly high.

As T.O. approaches around pulley, S turns his head to it, jumps up, chirping softly, turns, watches it pass him and depart, runs to it when it is 3 feet away, stops, watches it.

When it rounds pulley at other end, S runs to it, follows for 1 foot, pecking at it several times, watches it depart, pecks once at the ground, settles down on ground, head high, then head sinks downwards, eyes closing.

On the next four occasions, S gave no response to T.O.

After this, S runs forward to it, approaching at a distance of 3 feet. Chirps many times softly, does not turn with it, but faces opposite direction, stands, looking all about, settles down on ground, head just off the ground, eyes half closed.

As it passes again, S looks up at it, chirps softly, watches it pass (turning head) and watches it depart.
Thereafter, S looks up at it and walks about 6 inches towards it, as it approaches. Usually pecks once at it, turns, but does not follow. Occasionally S would not approach it, but merely watch it.

SOUND OFF:

S continues to look up at approaching T.O., move to it about 6 inches, turn, and watch it depart. In between these times, S would remain with body on the ground, head low, looking all around on the ground, with an occasional peck at the ground.

MOVEMENT OFF:

S's head is down on the ground just as the movement is turned off, his eyes are closed, and he remains like this until removed from the runway.

Chick No. 25: approximate age = 3 hours.

Initial behaviour similar to that of the first chick. In runway, S lies on ground, head up and looking about, for about 10 seconds. Few soft chirps then followed by half a minute of quietness. S looks down towards the ground, head moving to left, forwards, and to the right. Several more soft chirps. Head comes up, looks all around. Head goes down again, looking around the ground. Continues in this fashion, with occasional soft chirps, until:

SOUND ON:

S looks up, head quite still, stands up, quiet, moves forward about 2 feet, walking slowly, head jerking from side to side. Squats on haunches, head medium height, head goes lower, moves around near ground. Few soft chirps. Gapes three times, stands up, head high, body sinks back onto ground, head low.

MOVEMENT ON:

The T.O. rolls over S's body before he sees them, he turns, watches it, gives few soft chirps.

As the T.O. returns, S watches it, turns his head and body, watches it depart, few soft chirps.

The next time he waddles towards it (1 foot), pecks at it twice as it passes, (at the top of the lowest ball), shuffles forward after it for 6 inches. Observer gets strong impression that S can hardly use his legs.
As it approaches again, S shuffles towards it, pecks at it, chirps moderately loudly and frequently.

After this, S settles down, head down just off the ground occasionally pecking, but eyes half closed for most of the time. On next two occasions he does not react to the approach of the T.O. Thereafter he watches it approach, chirping a lot, waddles towards it, pecks at it (usually) and at the ground when it has passed, and would sometimes follow it for 6 inches to one foot as well. He invariably approached it whenever it was about 2 feet near him.

SOUND OFF:

S looks up and around to the right, then forwards again and to the left. Makes no noise, then head goes down to ground, eyes half closed, beak on the ground.

MOVEMENT OFF:

S remains on the ground, both body and beak resting on it, eyes half closed.

Chick No. 26; approximate age = 3 hours.

Initial behaviour similar to that of first chick. In the runway, S stood with legs bent underneath him, body high off the ground, rocking forwards and backwards, head at medium height, looking all around. Shifted left leg forward, and gave a few soft chirps after 5 seconds, quickly became louder. Moved forward 6 inches after one minute, then to the wall on its left, after 20 seconds more. Calling loudly almost the whole time.

This type of behaviour continued throughout this period.

SOUND ON:

Stood still, head stretched forward, quiet, for about 10 seconds, then gave a few soft chirps, and walked forward 4 paces. Head went down to near ground, pecked at or near right foot, walked forwards again, few soft chirps, then an unusual extended cry, of moderate intensity, and of peculiar composition, made as head came forward and upwards. Stood still after this, looking around, head at medium height, and quiet.

MOVEMENT ON:

The T.O. brushed against its body, before S saw it, S ran/shuffled sideways, losing balance and falling to the ground.
on its right side. Immediately stood up again, using its wings. Several loud calls at this time. Stood, head high, looking all around, calling loudly. Moves over to wall, and walks around a small area there. Does not appear to notice T.O. as it passes on next three occasions, then squats down on its haunches, quiet, as T.O. approaches. S watches it pass him, then stands up, few soft chirps, watches it depart. Squats down on haunches again, looking around, quiet.

As T.O. approaches again, S stands up; as it passes, he moves up to it, follows it for one foot, watches it depart further, settles down on ground, body flat, head low, pecks several times at ground, quiet.

Stands up as T.O. approaches again, walks to it as it passes, several soft chirps, pecks at it twice, follows it for six inches, stands watching it, turns away, sits down, body flat, head up and forward.

As T.O. approaches again, S turns head and watches it. It passes against his body, he stands up, loses his balance, quickly regains it, quiet, turns and watches it depart.

The next time, S stands up when T.O. is 2 feet away, turns, chirping, as it passes, walks one foot after it and watches it. Moves around in the interval, several soft chirps, lies down on ground, head low, pecks several times at ground.

As it passes the next time, S watches it, turning head only. Looks back down to ground, as before.

On the next occasion, S walks jerkily forward as it approaches (1 foot), turns head only as it passes, looks all around, still quiet.

The next time, he turns his head, watches it approach, pass, and depart. The same thing happens on the next occasion.

Then, S walks clumsily forward, stepping on one foot as he moves the other, watches it pass and depart, turning head and body.

Settles down on ground, head low and moving just above ground. Stands up as T.O. approaches, walks towards it (6 inches) turns, watches it pass, follows for about 6 inches, few soft chirps. Settles down again.

The next time, S stands up, walks towards it as it passes, and thrusts beak forward, rubbing it against the side of the lowest ball. Settles down again as it departs, head low, almost touching the ground, remains still.
Thereafter S does not get up again, but always looks up as T.O. approaches (about 2 feet away), turns head, and usually body, as it passes, watches it depart for about one foot, remains quiet.

**SOUND OFF:**

No change in S's behaviour.

**MOVEMENT OFF:**

Head sinks onto ground, eyes half closed. Remains thus for about half minute, then jerks head up, eyes open. Head quickly goes back down again (within 5 seconds), does not look at T.O., eyes close, quiet.

(2) **SECOND EXPOSURES**

Approximately 24 hours after the first exposures, the chicks were again placed, individually, in the runway. The target-object was the same (within each of the two groups) as the one used on the initial exposure. No sound was used; the T.O. was moving continually from before the chick was placed in the runway until after it was removed. Each exposure lasted for 15 minutes, and recordings were made in the same manner as previously. The chick was placed in the centre of the runway, facing the T.O., which was rounding a pulley wheel at the time.

**Results**

All of the chicks gave loud calls as they were released from E's hand in the runway. These ceased as the T.O. approached for the first time, except in the case of chicks 1, 15, and 18, who were moving near the walls of the runway, and did not appear to see the T.O. until it had moved around two or three circuits. Thereafter their behaviour was similar to that of the rest of the chicks.

As the T.O. approached, the chicks would turn either their head or head and body towards it. They would usually walk or run towards it. Then they would turn with it as it passed, and follow for about 18 inches, on the average, for the first six or eight trials. They then watched the departing T.O. for up to 2 feet. Some would run up to it again after a short pause, move with it for less than one foot, and watch it again. The intensity of these responses to the T.O. clearly diminished towards the end of the exposure. Most of the chicks pecked at the T.O. on a number of such occasions, and also pecked at the ground while, or just after, following it.
From the time when the loud calling ceased (usually when the T.O. approached for the first time; see above), no further loud calls were heard, but, in many cases, the chicks would chirp softly after pecking at the T.O., and/or while pecking at the ground as the T.O. departed. Such soft chirps were also frequently heard when the chicks were moving around, head usually near the ground, in the intervals between the approach of the T.O.

During these intervals the chicks would move around in an area of about 18 inches to two feet square, with head down near the ground. They would often peck at the ground, and would also raise their heads to medium height (beak horizontal) and look around them. Five of them lay on the ground, with head up, or with head down near the ground, during several of the intervals. One chick (No. 15) rested his beak on the ground, and closed his eyes, during two consecutive intervals, showing the typical response, however, (see above) as the T.O. approached.

At a sudden sharp noise (e.g., a door slamming somewhere in the building), the chicks would cease their current activity, raise their heads, usually cocking them slightly to one side, keep their heads forwards, or (less commonly) move them jerkily around. After 2 or 3 seconds, the chicks would resume their previous activity, or walk forward several paces, and then resume it.

Chick No. 21 stood preening behind its left wing for about 10 seconds, and then again 20 seconds later, during one interval between the approaches of the T.O. During the 20 seconds, the T.O. passed, and the chick showed a typical response towards it.

None of the chicks followed the T.O. for more than half the length of the runway, on any given occasion, including those which ran after it several times on the same occasion.
It should be stressed, at the start, that the "non-imprinting conditions" are not necessarily the normal conditions in which domestic fowl find themselves, nor are the conditions for the imprinting group necessarily typical in all respects of those in which other investigations have been performed. Thus, any statements made, with respect to the behaviour of either group, will apply only to the specific chickens observed—whatever application these statements may have to chickens in general can only be known after further investigation has been made, taking into account any procedural differences between this and other studies. While it is felt that the behaviour described in the previous chapter is fairly typical of chicks in general, both individual and group differences were found, and these were correlated with differences in the stimulus situation in many cases (e.g., with the number of other chicks present, and with the presence of a hen, etc.). Stressing this point guards against describing any given item of behaviour as instinctive or learnt, or by means of any other such "umbrella" terms.

One further initial point to be considered is that the "non-imprinting" groups were not non-imprinting at all, in principle at least—with the exception of the single chick in
group $1/0$. These categories are used at a descriptive level, solely to bring out the fact that the one group was not exposed to the more artificial experimental conditions, while the other group was.

The most obvious characteristic of the non-imprinting chicks was the alternation between periods of rest and periods of activity. With age, activity increased at the expense of rest. Secondly, as mentioned earlier, the movements of older chicks were better controlled than those of younger birds—in preening or walking, for example, the older ones lost balance less often than the younger ones. In line with the increased activity of older chicks, the distance they covered during locomotion became greater. Older chicks also pecked more often and did more preening than younger ones. One result of increased activity—of locomotion in particular—is to bring the animal into contact with a wider variety of stimuli. A pattern of behaviour which did not change in either form or latency, as far as could be judged, was the startle response. The fact that a noise, which would elicit this response during the chick's active periods, did not always do so during its rest periods, together with the fact that older chicks were active for longer than younger ones, is probably sufficient to account for the increased incidence of this response in the older chicks— in other words, if the startle pattern is taken as an indicator of anxiety, then, based on this behaviour alone, there is no evidence which suggests
that anxiety increases with age. This response, however, is not felt to be indicative of anxiety, but rather to precede any such state or response of that nature. Its function appears to be to alert the animal to a sudden change in the environment. This does not necessarily imply that it is a response to sudden danger, even though the animal may subsequently flee from the source of the sudden change in the environment (i.e., after having perceived or identified the new stimulus situation as being dangerous, or, at least, as one which has not been experienced before). An analogy may be drawn with the sounding of an air-raid siren during wartime—although, in adults and older children, anxiety responses may be, and are intended to be, conditioned to the sudden intense change in auditory stimulation, young children, at first at least, are not "alerted to the danger" by the siren, but are simply "alerted". For all they know, it might be a sign that the toyshops or candy stores are opening. The young chick must surely be thought of as corresponding to the young child, rather than to the adult. In support of this is the fact that the chick's behaviour reverted to its prior form within a few seconds after the disturbance; it did not give the loud calls usually referred to as distress calls, nor did it flee to the walls of, or around, the pen. In contrast to this, the broody hens showed the same startle response, but continued in that fashion for long after the chick had ceased to do so. It is thought that the hen, as a result of its experience on numerous
occasions in the past on which a sudden disturbance had led to the entrance of one of the staff of the farm into its living quarters, and to some form of relatively distressing treatment, would have had, like the adults when the siren sounded, anxiety responses conditioned to any sudden change in auditory stimulation. The young chick had experienced only two or three such events, therefore was alerted to the change, in a neutral sense, rather than being alerted in the sense of being emotionally aroused. The response appears to be reflexive in nature, involving several components, rather like the Babinski response in infants, but somewhat more complex.

Another behavioural item which is generally taken to be indicative of anxiety is defecation. This was infrequent on the first day, somewhat more frequent on the second. Does this imply that anxiety increases in similar fashion? Since defecation is a positive function of amount of food ingested, and since it was noted that pecking increased with age, a much more direct explanation suggests itself.

With regard to anxiety responses on the occasions when the chick was violently disturbed, namely, when it was taken from the incubator, and when the water was changed (via the hose) at the end of the first day, there was no evidence whatsoever which suggested either that a chick, one or two hours of age, was not extremely disturbed by the former event, or that it was more strongly disturbed later than earlier. The chicks, removed from
the incubator at a younger age than certain slightly older ones, struggled and called loudly when E picked them up to at least the same degree as did the slightly older ones. All chicks were removed and taken to the observation pen (being weighed en route) at an age earlier than that at which Hess (1959), for example, suggests that they show fear responses. Clearly, some of what is referred to above as struggling consists of presumably reflex responses to changes in equilibrium, which, per se, do not necessarily imply any emotional state such as fear or anxiety, but, even if this were the complete explanation for such movements, the other forms of behaviour shown simultaneously (e.g., the calling, pecking(?), and running around the small cage if E did not pick up the chick successfully), would still suggest an explanation in terms of anxiety. With chicks hatched within a few hours, and left undisturbed in a constant environment for these few hours, one could equally well argue that the effect of the sudden disturbance would be greater, the more recently the chick had hatched.

With regard to the changing of the water in the pen at the end of the first day, all chicks were disturbed by this event, as seen by their behaviour. Since, however, by this time the chicks were at the age at which anxiety or fear responses have previously been observed, this provides no further evidence for or against the present position that anxiety can be aroused, and manifest in the chick's behaviour, from the time of hatching.
rather than from nine to ten hours thereafter (Hess, 1959; Moltz, 1960).

It is granted that, for much of the first day, the newly-hatched chick spends a good deal of time resting, and that, during this time, it does not show the startle response as readily as when it is more active during that day. It is also granted that the chick may not flee so much at this time as it does later. It cannot be believed, however, that, ipso facto, the chick can be said to show no anxiety, or to be in a low-anxiety state during the first few hours after hatching—given the occurrence of sudden intense changes in the chick's perceived environment. For ease of expression, the term "sleep" will be used to refer to those occasions on which the chick is lying down, with head on the ground, and eyes closed, and when its only observable movements are breathing movements. One of Moltz's (op. cit.) points is that since the animal "sleeps" for much of the time, it can hardly be said to be in a high-anxiety state. In one sense, this is quite clearly true, but it is also misleading. Given a sleeping chick, events which would lead to anxiety responses, were it awake, do not do so now. Even if a chick slept for the whole of twenty-four hours, there would be no evidence that certain events, which did not arouse anxiety in the sleeping animal, would not do so if the animal were awake when they occurred. There is an alternative to saying that sleep indicates the absence of anxiety; that is to maintain that sleep functions
to reduce the perceived environment to an extremely low level. It is not so much the case that the threshold for anxiety responses is high, as that the perceived environment is minimal.

It will be clear that these two statements are not necessarily contradictory. The first may simply imply that, at the time when the animal was going to sleep, events were not occurring which elicited anxiety responses, while the second statement implies both that, given the sleeping animal, the occurrence of these events does not now elicit these responses, and that, had they occurred at the time when the animal was going to sleep, it would not have slept, but would have shown anxiety responses.

Referring this to Moltz's two-part theory of imprinting, it will be seen that it applies to the first part only—the state of the animal during its initial exposure to the target-object, and the effect of the target-object on the animal at this stage. The most relevant portion of Moltz's article begins on page 303, under the major heading "Why Following Occurs".

Anxiety will be defined as an internal emotional state of the organism, this inferred state being indexed by such observable events as distress calls, startle behaviour, defecation, etc.

Later, he states (pp. 304-305):

A low anxiety state can be thought of as involving a particular constellation of visceral and cardiac activities, some fraction of which can become conditioned to previously neutral stimuli.
After discussing the ease with which birds perceive movement, he says (p. 304):

Although, there is no reason, of course, to assume that sensitivity to movement is greater during the critical period than at any other stage in ontogeny, the fact that the bird does possess this sensitivity at a time when its anxiety level is low makes the critical period important with respect to the organization of the following response. Its importance seems to be related entirely to the fact that it provides the occasion for the conjunction or association of a low anxiety drive and an attention evoking object.

The behaviour of the bird, during its initial exposure, is as follows (p. 303):

A duckling between 8 and 10 hours old when placed in this apparatus for the first trial, usually exhibits very little locomotion. The animal frequently drowses and appears to attend to the object only when it passes near him. During this time none of the conspicuous signs of anxiety is present.

During the second exposure:

However, when the animal is reintroduced to the apparatus 24 hours later for the start of the second 25-minute test trial, it emits many distress calls and frequently runs about the alley for a brief period before beginning to follow. Once following begins, the strength of the response increases progressively until the duckling comes to devote the entire period to pursuing the test object. As long as it remains in close proximity to the object neither distress calls nor startle responses are usually emitted.

Moltz's position rests on the following conditions:
(1) That the definitions of anxiety response and anxiety state are meaningful. This implies that the behavioural indices of the anxiety state constitute an identifiable class of behaviour, separate from any other class such as eliminative behaviour, sexual behaviour, feeding behaviour, warming behaviour, etc., OR that, if any items from these other classes constitute part of anxiety behaviour, then these appear in a fixed, unique pattern defined in terms of temporal sequence, relative duration, relative strength, or some other relational property).

(2) That the labels affixed to this class of behaviour, namely, "anxiety response", "anxiety behaviour", or "anxiety state", "anxiety drive", etc., relate the observable unique pattern to the internal and external stimulus conditions, whose occurrence is at least positively correlated with that of the behaviour in question. This means that these stimulus conditions also must be identifiable and unique in the same sense as referred to above, and that the use of the labels to relate the behaviour to the conditions in which it arises does not conflict with their common, or accepted usage. If the proposed labels are new, and therefore arbitrary, or if it is proposed to use them in a novel, and therefore arbitrary, sense, some logical justification—external to the relation itself—must be presented for doing so.

(3) That the definitions so reached include every relevant item, at whichever level (e.g., neurological, or physiological, or
psychological) of discourse is used.

(4) That the chick is in a low anxiety state during the initial exposure. This means that the definition and usage of the term "low anxiety state", or a synonymous term, must meet the above three conditions, in addition to it being shown to be appropriate at this experimental stage.

(5) That the chick is in a high anxiety state during the subsequent exposure (see the last condition above).

(6) That the various psychological processes suggested by Moltz (classical conditioning, reinforcement learning, etc.) do, in fact, occur. Since, at best, these can only be operationally defined, it must be shown merely that a parallel exists between the procedures used and results found in other cases where the terms are used, and those used and found in the present case.

The present writer feels that these conditions are not adequately met. In the first place, the present results indicate that distress calls and flight behaviour are not the only indices of anxiety, and, at the same time, that these are shown by chicks when taken from the incubator within one or two hours of hatching. While the results do confirm that such chicks spend a good deal of time "asleep", it has been suggested that this by no means provides evidence that the animals are functionally incapable of showing anxiety behaviour during the first day. The fact that, after a few hours, the chicks' locomotor abilities are such that
they can now show this anxiety by means of flight, merely makes the task of identifying their anxiety somewhat easier. Similarly, the fact that such behaviour is more common on the second day, as Moltz found, appears to be a result, not so much of the development of anxiety, as of this increased locomotor ability, coupled with the greater number of instances of novel stimulation which the increased locomotion brings about—in other words, anxiety is now more easily identified and more often elicited. Previously it was harder to identify, and less often elicited (because the animal was asleep for a greater proportion of the time, and could locomote only poorly even if awake). This would suggest that conditions 1, 3, 4, and 5, above, have not been met in full. The second part of condition 2, referring to usage of labels which include the term "anxiety", need not be considered here, as the use of the term does not appear to conflict with common usage, whether, in this usage, it is vacuous or substantive. This has been briefly referred to in Chapter I. The first part of condition 2 may be said to have been met, in so far as relating the behaviour or state labelled "anxiety" to the stimulus conditions is concerned—at least, once the chick is in the runway—even though the identity, uniqueness and inclusiveness of what is referred to by the term may be questioned. Since the processes postulated by psychologists to underlie behaviour (condition 6) are, to a great extent, arbitrary, unidentified (at the moment at least) in the complementary "lower" levels of discourse (e.g.,
neurophysiology), and subject to revision not only with the introduction of new data, but also with the introduction of new terms, new meanings of terms, new attitudes, and new fashions, and since a prima facie case for the presence of an operational parallel in this instance may be made, it is of importance solely to examine the theory in the light of some new elements in the animal's behaviour, and in its environment, which may be of significance. Before doing this, however, two further aspects of Moltz's theory will be considered, and two other theories, apart from this and Lorenz's, will be stated again.

Moltz cites the work of Moltz, Rosenblum and Halikas (1959) in support of his hypothesis that strength of following is related to anxiety. These investigators, in effect, negatively conditioned the experimental animals to the imprinting runway by giving them electric shocks in the runway, but in the absence of the target-object. Other animals were similarly shocked outside the runway, or were placed either inside the runway, or outside it, without being shocked. They found that the animals negatively conditioned to the runway (but not to the target-object) subsequently showed much greater following in the runway than did the others. This is hardly surprising, since, subsequently, the only stimulus in the runway, to which the animals had not been negatively conditioned, was the target-object. The shocks were given prior to the seventh ordinary imprinting exposure (i.e., one 25-minute exposure on each of the preceding 6 days, commencing on the day
of hatching). It is doubtful whether this result provides any support for the hypothesis proposed.

With regard to the postulated two different degrees of anxiety during the first exposure and during the second, low and high respectively, and to the conditioning (Day 1) and drive-reduction (Day 2) which are claimed to underlie the occurrence of following, a serious difficulty arises. It will be recalled that Moltz states (p. 303) that, on the first exposure, a few hours after hatching, the animal "frequently drowses and appears to attend to the object only when it passes near him." The animal is said to be in a low-anxiety state, and this low anxiety, it is claimed, becomes associated or conditioned to the target-object, which appears to be the only, or almost the only, part of the total stimulus situation to which the animal attends. The present results (obtained from chicks, rather than from ducklings, which Moltz used) indicate that this is only relatively so, that the animals may attend to, and show several forms of behaviour in, other parts of the runway, and that being removed from their living quarters and being placed in the runway elicits anxiety behaviour in them. Be this as it may, however, even in terms of Moltz's argument, a contradiction arises—let it be supposed that the typical bird does sleep, or at least drowse, during most of the first exposure. It would seem reasonable that the drowsy animal should be described as being in a low anxiety state. It would, further, not be unreasonable to say that the
drowsy animal did not attend to the imprinting environment, by and large, and, therefore, having attended to almost no part of it, could have almost no part of it associated with, or conditioned to, this low anxiety state, which it is in while not attending to the stimuli from the runway. Indeed, one has to spend large sums of money to learn while one is asleep. But then, some sudden fluctuation of retinal illumination, produced by a moving object, and greatly enhanced beyond that experienced by mammals, due to the bird’s possession, in its eyes, of a highly plicated pecten projecting from the point of entrance of the optic nerve into the vitreous humour, (Moltz, p. 304), brings the animal out of its slumbers. This is the moment of conditioning. The state the bird is in, on suddenly being aroused, is to be conditioned to the presence of this arousing object. Is it the case that these conditions—the only ones relevant, as has been seen, to the proposed conditioning—represent low anxiety?

The only really conclusive means of determining how anxious the animal is at this time would be to measure whatever physiological changes may be shown to be related to or to constitute the anxiety state. There are two types of problem associated with this, however, one practical and one theoretical. The practical one arises in that some recording device must be attached to the animal which is sensitive enough to pick up the changes, which provides a record of these changes for analysis by the observer, which does not affect the anxiety state at the time of imprinting, and which does not influence the overt behaviour of
the animal at that time (e.g., by requiring trailing leads, or
by being relatively heavy). It is conceivable that, by injecting
a radio-active dye into the animal's bloodstream—one which would
remain therein until the experiment had been run—and by noting
the rate at which this passed through its heart, one could achieve
the desired data. This would avoid such problems as trailing
leads etc., since the recording equipment need not then be
attached to the animal, and need only pick up the changes in the
motion of the dye as it moved through the heart. One could not kill
the animal and check its hormonal balance, since this would be
affected as it was being caught and killed, and in any case, the
kind of measurement required must be available during subsequent
trials. In the absence of such data, and even ignoring the
present evidence, it seems unlikely that what is conditioned to
the arousing (target) object is low anxiety. If anything, the
animal would appear to be momentarily in a relatively high anxiety
state. Since it is in this moment that the conditioning takes
place, the stated fact that the animal is drowsy, and therefore
in a relatively low anxiety state, for the rest of the time, is
entirely irrelevant.

The theoretical difficulty with such physiological
recording is that in order to show that any given measure is an
index of anxiety, one has to at least show that it is very highly
positively correlated with overt behaviour which is known with
certainty—for reasons external to the physiological recordings—to
reflect anxiety. This does not arise with humans as subjects, for they can indicate verbally when they feel anxious, with some degree of accuracy, one has to assume. The problem is to decide, in the case of lower animals, which behaviour pattern, or which items, reflect anxiety. Moltz's list (see above) included "distress calls, startle behaviour, defecation, etc." It has already been argued that emotion should not be "read into" startle behaviour, when it is observed in neonates, at least, and defecation measures have been questioned on other grounds. Despite the previously mentioned fact that the birds' calls vary along various continua, as judged by the human ear rather than as measured by the spectrograph, and that the calls of one bird may not be so loud as those of another, it is admitted that the loud, sharp, almost ear-shattering calls of chicks do appear to be distress calls. Unfortunately for Moltz's analysis, the chicks used in this study almost invariably gave these calls when only a few hours old, and during the first exposure--the time when Moltz claims that their anxiety is low. It may very well be that these will be shown to be related to such factors as heat loss, and that the term anxiety--under these conditions--is too global to be useful. What can probably be said is that when these "concrete" conditions are in effect (e.g., when the animal is cold), these constitute anxiety. Not only have the items included in Moltz's definition of anxiety been questioned, and not only have these been found to occur in newly-hatched chicks (which
refutes the proposed theory), but also it has been suggested that the chick is aware of far more of the runway than simply the target-object. What appears to be the case is that whenever (at least at first) the target-object comes close to the animal, it is alerted to a greater degree than when the target-object is distant. If one pictures a graph, plotting anxiety-level against time, Moltz's position would seem to mean that a more or less straight line, starting and remaining at a low level on the anxiety axis, and therefore running close to and parallel with the time axis, could be drawn on that graph to indicate the chick's anxiety level during the initial exposure. The present suggestion is that such a line would be accurate for the greater part of the time, but that sharp peaks would be needed to represent the very brief, but crucially important, moments when the moving target-object passed close to the animal. Since the sum of all these moments would constitute a relatively small proportion of the total time, the overall "general" line would still indicate low anxiety, but relatively high anxiety would have to be claimed as being the state which was conditioned to the presence of the target-object.

It is interesting to note that, if such were the case, Moltz's analysis would hardly need modifying. If it is remembered that this anxiety is said to be caused by the animal's perception of novel stimuli (Moltz, p. 305), then the analysis could be modified to read as follows:
On the first exposure, the animal attends only to the target-object, and then only when it is near him. This means that the novelty of the target-object arouses momentary high anxiety, and this is what is conditioned to that stimulus. It cannot show this anxiety in the most obvious fashion since it cannot run (flee) to any great extent.

On the second exposure, the animal attends to many other features in the runway, as well as the target-object. These other features are being attended to for the first time, and therefore elicit high anxiety. The target-object, however, is being attended to for the second time, and, by definition, is less novel. It therefore elicits somewhat less anxiety than the rest of the runway does. (N.B. During the first exposure, the target-object captures the attention of the animal many times, not just once. In the present experiment it did so roughly once every thirty seconds for a period of about 15 minutes.) Thus, as Moltz suggests, if the animal is near the target-object, this serves to reduce its anxiety on the second exposure. On each subsequent occasion, the target-object will have been attended to more often than will the rest of the runway, hence it will always be less novel and have the advantage as a reinforcer. The critical period is still accounted for in terms of Moltz's analysis, so need not be discussed again. Theoretically, one could argue that the present suggestions do not even require the introduction of any form of learning--although this would only
end in semantic discussion. The only postulates needed are two—an anxiety response to novel stimuli, and memory. Since, in conventional terms, one would say, "The animal has learnt to follow the target-object," a compromise might be effected if learning were taken simply to describe (not explain) a class of events. Used in this capacity, the term would not imply a neurological or any other change within the subject—the only such change would be implied by the term "memory".

The reason why it was suggested earlier that the only conclusive test of Moltz's anxiety theory would require physiological measures is that, although the present analysis seems more appropriate to the behaviour of the chicks, the same evidence which supports Moltz's theory also supports this one. The position is awkward in that if the animal's anxiety is made to increase during the first exposure to the runway, at the moments when it is attending to the target-object, then, in effect, the animal will have been negatively conditioned to the target-object. Conversely, if the animal's anxiety is decreased at these vital moments, then the animal will remain asleep, or drowsy (as Moltz claims it does for the rest of the time), and will not notice the target-object. It seems very significant that several animals, towards the end of the first exposure in the present experiment, having at first paid attention to the target-object when it was near them, then lay down and apparently slept, paying little further attention to the target-object. Since the
only essential difference between the present analysis and Moltz's concerns the initial exposure, the behaviour of these animals appears to support this analysis rather than the former.

The other two theories which should be mentioned again before suggesting a factor which appears to reconcile both them and Moltz's theory are those of Hess (1956/57) concerning energy expenditure, and of Hinde, Thorpe, and Vince (1956), Hinde (1955), and Hess (1959). Hess (1956/57) obtained results which seemed to indicate that the strength of the following response was a function of the effort expended in following. Length of exposure was not the crucial factor, and if obstacles were placed in the bird's path, such that greater energy was expended in crossing them, distance followed was not necessarily the only index of energy expended. The other theory is similar to Moltz's, but was not fully developed. It states that the critical period depends upon two factors—the ability to locomote, which develops with age, and the onset of fear reactions.

Heat loss/heat production, it is thought, provides an opportunity for synthesis. It is assumed that when an animal is cold, several autonomic changes occur which serve to facilitate the retention of whatever heat it has, as well as to increase its heat production. Shivering and movement, in particular, will restore the body's heat. To the writer's knowledge, imprinting experiments, whether in the field or in the laboratory, have not been held under conditions in which the temperature was the same
in the animal's living quarters and in the runway (or test area). While one is careful to ensure that the newly-hatched bird has hot living quarters (e.g., in an incubator), one usually does not insist that the runway be maintained at the same high temperature. Even if the study is a field one, and the day is hot, the animal is provided with some form of extra heat in its living quarters. In the present experiment, for example, the animals' boxes were placed very close to a large radiator, while the runway was some distance from there. (N.B. This factor did not emerge until after the experiments and observations had been completed). The "non-imprinting" chicks were placed in a pen in which the temperature under the lamp was 10 degrees higher than it was some five or six feet away, and these animals remained under, or near the lamp for most of the time, particularly on the first day. The hens, it will be recalled, remained at the far end of the pen for most of the time. Now the hens were well supplied with feathers, and the body temperature of a broody hen rises slightly above its level when the hen is not broody, whereas the chicks had only an inadequate supply of down, which by no means covered their bodies, and which was still damp in many cases when the birds were removed from the incubator. These are the ones who would feel the cold most strongly. It has also been established that newly-hatched chicks give distress calls when they are cold (pp. 22-23 above), and distress calls, it has been concluded, provide the surest indication of anxiety. In
order to become cold, the non-imprinting chicks had to move from where they were placed under the lamp. They did this, from time to time, even on the first day, but did not give distress calls. It is suggested that they did not do so because, in fact, they did not become cold when away from the lamp due to the fact that they had to use their muscles to stand up and to move away from the lamp. They moved around almost continually when away from the lamp, pecking at the ground and preening from time to time, and then lay down again under the lamp.

The chicks who were used for the artificial imprinting, on the other hand, were taken from a higher to a lower temperature, and left there with no direct heat source. Almost without exception, they stood or lay down for about 10 seconds, then began calling softly, stood up if they were lying down, moved around and called loudly and continually. In some cases the "gock" recording caused this calling to cease, which can hardly be accounted for in terms of heat production, it is granted, but it is not suggested that heat loss/heat production is by any means the only relevant factor--merely that it is an important one which has been overlooked to some extent at least. In most cases the birds continued their distress calls until the target-object began to move, when they moved in towards it and with it for a short distance. Now if the animals were cold, as they almost certainly were, this movement would serve to produce heat. The problem still remains as to why they should attend to the target-
object in the first instance. It is suggested that this response is comparable to the startle reaction previously described and discussed. It is probably of a reflex nature, and is elicited by retinal flicker. It would probably best be classified as an elementary component of curiosity or exploratory behaviour, rather than as an anxiety response. Whereas the startle response is usually given in situations which lead to some form of relatively distressful treatment (cf. the behaviour of the experienced hens, as opposed to the naive chicks), and therefore soon becomes an anxiety response, curiosity behaviour, although it may start as a similar reflex response, develops in those situations in which the eliciting stimulus (a) persists at least for a short while, (b) remains at about the same intensity, and (c) does not lead to distressful treatment. Once the eliciting stimulus loses its novelty, the response may be expected to decline, or other responses may take its place (e.g., in this case, if following the target-object has been positively reinforcing, this may be the form into which the response will develop).

Berlyne's work (1951) centres upon this curiosity or exploratory factor.

Coupled with these two factors, temperature and exploration, is the fact that at an age of a few hours chicks do not locomote well. This would account for their relatively poor following on the first day (see Chapter III above, and Moltz, 1960). The energy expended by these chicks on the first day,
however, may well be equal to or greater than that expended on the subsequent days when they follow more continuously. It is probable that even to maintain its head at medium height in front of its body, even to remain standing, even to simply turn towards the moving target-object, requires, at this age, a tremendous amount of effort. This is where Hess's earlier finding (1956/57) is relevant—the effort expended in maintaining its orientation towards the target-object as it moves past results in increased heat production, which serves to reinforce the behaviour in question. Since, on subsequent occasions, the chick is drier, its down provides a more adequate insulator for its skin, and its developing muscles enable it to move with less effort, it would have to be postulated that the originally reinforcing behaviour now continues as a habit somewhat less dependent upon the reinforcement than initially, were a complete theory being developed here. This is not the aim of the present discussion. The writer merely wishes to bring to attention a factor whose importance, appears to have been overlooked in analyses of the animal's behaviour in the imprinting situation. At the same time, such a suggestion must be put forward since it appears to underlie both the anxiety and energy-expenditure theories, and therefore deserves, at the very least, to be put to experimental test. This can readily be done, of course, by varying the temperature in and around the runway, and between the animal's living quarters and the runway. If this factor turns out to be unimportant, at
least it will not need to be raised again, and the fact that it provides a common basic element which appears to underlie both groups of theories must be put down to coincidence. It has already been introduced in connection with the behaviour of Harlow's monkeys (Chapter I above) and when applied in this fashion it does appear to be more than trivial, which it was first thought to be by the writer.

Whether or not this factor turns out to be important, it does represent the sort of thing which must be sought out if explanations of this type of behaviour are to progress from stating correlations to showing causes. The question must be asked: What causes the anxiety? What makes the animal give distress calls in this situation? How is it that the expenditure of energy leads to the development of stronger following? The answer to these questions must come from many complementary disciplines. The behaviourist may be content to show that a reliable correlation exists at his level of discourse, but the physiologist, the neurologist, the histologist, as well as the neuro-chemist and the embryologist, will not rest until they have gone beyond the correlation to the underlying cause.
CHAPTER V

SUMMARY AND CONCLUSIONS

The literature relevant to imprinting has been reviewed. It has been suggested not only that explanation of the behaviour remains somewhat elusive, but also that the behaviour has been inadequately described. The present observations indicate that following is but one significant aspect of the animal's behaviour in an imprinting situation. Several other features have been examined, including heat production and maintenance, and what is best classed as curiosity or exploratory behaviour. Evidence has been provided that behaviour in response to distressful conditions—normally referred to as anxiety behaviour—appears in the chick from the time when it is first removed from the incubator soon after hatching. Stress has been lain on the necessity for more intensive analysis of the factors which lead to what is termed anxiety, and of the ways in which the animal in the imprinting situation responds to these factors. Attempts have been made to present the situation as the animal experiences it, which is felt to be the prerequisite of any explanation.

In a non-imprinting situation, the behaviour of newly-hatched chickens in various groups was found to contain many forms, which were common to all the animals. The general development of behaviour was found to follow a similar pattern in each group. A number of individual and group differences were found,
however, which were correlated with differences in the stimulus conditions between those groups. The more young chickens (ranging in number from one to four) there were in a group, the greater was the duration of activity of the members of that group between their rest periods. An exception to this occurred in the group of two newly-hatched chicks alone in the observation pen—this group was far more active than most of the others, equalling the activity of the four-member groups. The presence of a broody hen attracted a certain amount of the chicks' attention—they watched the hen, and approached her, running beneath her body. The more chicks there were in a group, the less this happened. The hen attacked the approaching chicks, pecking them viciously, and throwing them from her. In the case of the single chick with the broody hen, this happened over fifty times during the first day on which they were together, then, when the observer returned the next day, the hen was brooding the young chick, and continued to do so throughout that day. In no other case did a hen brood any chicks, and in no other case did the chicks approach the hen more than about 10 times in the two-day period. Chicks in groups, as opposed to a single chick, oriented almost all their behaviour towards each other. They showed two forms of behaviour, in particular, which the single chick did not (and could not) show—mutual preening and huddling together. One chick of a group of several would not remain apart from the group for more than a few seconds—except in one group of three, where two of the
chicks appeared to be resisting the approaches of the third (unless they were lying beneath the lamp). As chicks grow older they become more active, remain active for longer periods, and venture further from a heat-source. For the first few hours their locomotor abilities are poor, and they spend a good deal of time lying near a source of heat. Their movements at this stage are badly controlled; their balance is poor. On the first day out of the shell they eat little and defecate little; on the second day both these forms of behaviour increase in frequency. Distress calls may be given not only from the time of hatching, but also while the chick is still inside the egg. Head and mouth movements are almost continuous within the egg. As the chicks grow older, they become drier, and their down becomes thicker—at first it is damp, and barely covers their skin. A clear-cut startle response is given, at all stages, upon the occurrence of a sudden intense change in auditory stimulation. This occurs less commonly when the chick is apparently sleeping than in one of its active periods. At several hours of age the chicks flee from a novel auditory and visual stimulus, which is presented suddenly and intensely (a hose is pushed across the wire-mesh walls into the cage as a means of replenishing the water at the end of the first day). All these forms of behaviour are thought to be relevant to an analysis of the processes underlying imprinting; almost all of them are shown in the imprinting runway, and the chicks struggle, peck, run, and call as the experimenter reaches into their living quarters to remove them
and carry them to the runway, when they are a few hours old.

Several theories of imprinting are examined in the light of the observations. Emphasis is laid on the stimulus conditions, the physiological state of the animal, and its behaviour, from before it hatches until it is exposed to the imprinting apparatus, and during the exposure(s). Heat-producing behaviour and curiosity behaviour are stressed in connection with these theories because they appear to have been overlooked, and, at the same time, provide a common element which may underlie these theories. An analysis in these or similar terms, it is suggested, will pave the way for the establishment of the cause or causes of the behaviour in question, and to this end the co-operation of the various other biological disciplines is invoked.
175

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