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THE EFFECTS OF RESPONSE CONTINGENT AVERSIVE STIMULATION ON THE ACQUISITION OF IMPRINTING

by

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ABSTRACT

Hess (1964, 1973) has suggested that aversive stimulation, in general, facilitates imprinting and many authors have reiterated his claim. However, the study on which he bases his conclusion (Kovach & Hess, 1963) used only response independent shock; furthermore, there are several methodological problems as well as errors in data presentation within this study. To date there have been no studies which have investigated the effects of response dependent aversive stimulation during imprinting. Therefore, the purpose of the present study was to assess the effects of response contingent aversive stimulation during the acquisition of imprinting.

Twelve groups of ten subjects each underwent an imprinting experience. A 3 X 4 X 4 design was used; there were 3 groups of subjects differentiated on where each group received the shock and 4 levels of shock intensity within each group (0, 1, 2, or 3 ma.). In addition, 4 training trials were conducted for each subject. The effects of the aversive stimulation were assessed, both at the time of presentation (training) and again 24 hrs. later (testing).

Significant differences were found for shock intensity during the training session but not during the testing session. During training, as the intensity of the shock increased, latency to approach the stimulus also increased. No other statistically significant differences were found either in the training session or in the testing session. The results are discussed and are not found to support the above assertion made by Hess.

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REVIEW OF THE LITERATURE AND STATEMENT OF THE PROBLEM

Imprinting has been defined as the formation of a social attachment by a young precocial bird towards certain specific objects and is often considered an "instinctive" behaviour in those species in which it occurs (Sluckin, 1965). Furthermore, the formation of this filial bond may occur very quickly; some authors have suggested that only a few minutes of exposure are sufficient for imprinting to occur (Hess, 1973; Martin & Schutz, 1975). Although imprinting experiments differ greatly in detail, they usually comprise two distinct stages: a period of training during which the subject is exposed to the imprinting object, and a subsequent testing period during which the degree of attachment between the subject and the imprinted object is measured (Bateson, 1966). However, ideas of what constitutes an adequate measure of attachment, and how such measures reflect attachment vary greatly. For example, the proportion of time spent following the imprinting stimulus (Barrett, 1972; Barrett, Hoffman, Stratton, & Newby, 1971; Campbell & Pickleman, 1961; Hess, 1956, 1959; Kovach & Hess, 1963) has been used, with greater following presumed to reflect greater attachment. Other measures and indications of imprinting have included decreased latency to approach the imprinted stimulus (Gottlieb, 1966; Gottlieb & Simner, 1969), decreased distress vocalizations in the presence of the imprinted object (Hoffman, Eiserer, Ratner, & Pickering, 1974; Zajonc, Markus, & Wilson, 1974), or a preference for the imprinted stimulus in a choice situation (Ramsey & Hess, 1954; Sluckin, 1965). To date, however, there has been no adequate test of the interrelationship between these various measures of imprinting. Nevertheless, the following response does appear to be the most widely used measure of attachment as judged by the number of studies using this criterion.

When Lorenz (cited in Sluckin, 1965) originally defined the term "imprinting" in 1935, he was also the first to postulate important differences between it and other forms of learning, specifically, classical conditioning. He gave two main reasons for his distinction: first, imprinting was confined to a short, well-defined period in the early life-cycle of the subject, a characteristic not generally true of other learning processes; and second, the formation of an attachment appeared to be irreversible. "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" (Lorenz, 1937, p.264). These statements were challenged by many researchers (c.f., Sluckin, 1965), however, who failed to find empirical support for them. Indeed, in following years Lorenz changed his views; he was later to state that imprinting may definitely be a type of conditioning process (cited in Sluckin, 1965).

More recently, however, Hess (1959, 1964, 1973) has also stated that imprinting is a unique process and has postulated five distinguishing characteristics that differentiate imprinting from what he terms "association learning" (although as Sluckin, 1965, remarks, it is somewhat uncertain what he means by "association learning"). First, Hess believes that there is a certain limited but well-defined period in the animal's life-cycle during which imprinting occurs. This postulate is the same one that Lorenz (1937) had espoused. Furthermore, "such limited 'critical periods' ... have never been found in cases of association learning" (Hess, 1964, p.1128). Second, the drugs meprobomate and carisprodol differentially affect learning and imprinting. The application of these drugs seriously impairs the imprinting process while they have little, if any effect on learning processes. Third, the strength of imprinting is a logarithmic function of the amount of energy expended during the training process; that is, the greater the effort expended during the imprinting experience the more a subject will subsequently follow the stimulus. In "association learning", however, spacing of trials appears to promote better learning, at least according to Hess. Fourth, primacy of experience rather than recency has a greater influence in the formation of an attachment while in "association learning, whatever has been most recently learned has greater influence on an animal's behavior" (Hess, 1964, p. 1129). Fifth, painful or aversive stimulation enhances imprinting to a stimulus while Hess (1964) claims that the opposite is true in "association learning".

These statements made by Hess have led to a number of experiments specifically designed to test his claims and, in general, there has been little empirical support for them (c.f., Bateson, 1966). Little research has been done on his fifth postulate, however, and as recently as 1973, Hess has continued to maintain that aversive stimulation facilitates imprinting. It is this fifth postulate, then, that formed the basis for the present research.

Before reviewing the evidence relating to the effects of aversive stimulation on imprinting, it should be pointed out that there are two different aspects to the assertion made by Hess (1964, 1973). First, although Hess (1964, 1973) appears to imply that aversive stimulation, in general, facilitates imprinting, it is important to specify the experimental operations which lead to the delivery of the noxious stimulus.[1] Generally, there are two different types of shock delivery schedules that may be used: either a response contingent schedule or a non-contingent (response independent) schedule. In a response contingent situation a subject is punished for emitting a particular behaviour.[2] In the imprinting situation, for example, a subject may be shocked for approaching, or for following a particular object. On the other hand, in the response independent situation, a subject is given shock independent of its behaviour; often the passage of time serves as the basis for determining when shock will be delivered. Furthermore, it is important to specify clearly the schedule of the aversive stimulation, for as Church (1963, p.374) has stated, "the performance under conditions of response contingent punishment is radically different from that under response independent aversive stimulation". Therefore, a review of the literature concerning the effects of aversive stimulation in the imprinting situation should specify how an experimenter programmed the delivery of the noxious stimulus. Second, it would also appear important to specify when the aversive stimulation is introduced into the imprinting situation, that is, whether the aversive stimulation is applied during the acquisition of imprinting or if it is applied after the response has been acquired. The effects of the aversive stimulation may be different in the two cases although this possibility is largely based on intuition. Thus, in the following review, this aspect of the situation will also be specified.

In support of his claim that aversive stimulation facilitates imprinting, then, Hess (1964) relates an anecdotal account of a duckling which followed a human closer after that individual had accidentally stepped on the animal's toes. In a more rigorous experimental situation, Kovach and Hess (1963) investigated the effects of aversive stimulation upon the following response of young chicks. In the first of the two experiments, the subjects were placed either in an experimental or in a control group and were tested at either 18, 32, or 48 hrs. of age (post-hatch). All subjects underwent an imprinting procedure in which each chick was given the opportunity to imprint to a blue ball which was suspended above the floor of a circular runway. During the single exposure session, the subjects were exposed to the stationary ball for 10 min., followed by 15 min. in which the imprinting object circled the runway. During the 25 min. session, subjects in the experimental group were given shock (3 ma - ½ sec. duration) based on decreasing time intervals. The number of feet that each subject followed the imprinting object during this session was recorded and analyzed. In the second experiment, another age group was added (14 hrs. of age) while the 48 hr. age group was eliminated; subjects were then divided into three experimental conditions (differentiated on the basis of different intensities and frequency of shock) or a control group. One experimental condition was similar to the one in the first experiment while the other two conditions received shock on a fixed-interval time basis.

The results indicated that experimental animals which were shocked followed significantly more than did control subjects at 14 and 18 hrs. of age if the shocks were either infrequent but strong (11 shocks - 3 ma each), or frequent but weak (27 - 1 ma). Older chicks (32 hrs. and 48 hrs. of age) followed significantly less under these two shock conditions. Furthermore, strong and frequent shocks (27 - 3 ma) did not affect the amount of following in subjects that were 14 hrs. old, but seriously interfered with it at all later ages. Therefore, the authors argue, "whatever the underlying mechanism may be that is perhaps associated with the development of fear, it is not only a limiting, but also a facilitating factor" (p.463). Many authors have since relied on this study to state that aversive stimulation does facilitate imprinting during a short period in the bird's development (Burghardt, 1973; Hess, 1973; Hoffman & Ratner, 1973; Scott, 1962; Smith, 1969; Solomon, 1964).

There are, however, several methodological problems, as well as errors in data presentation, that make it difficult to interpret this study by Kovach and Hess (1963). First, in most studies of imprinting, a subject is defined as following an object only if it is within some specified distance of the stimulus object (Gossup, 1974; Graves & Seigel, 1974; Kovach, 1971a, 1971b; Stettner & Tilds, 1966; Thompson & Dubanoski, 1964). Despite the importance of specifying the criterion used, Kovach and Hess (1963) provided no details on how they defined the following response. Second, although in the first of the two experiments the authors reported delivering 11 shocks to the subjects, only 10 are accounted for in their breakdown of the delivery of the aversive stimulation. In a subsequent article Hess (1964) reports that the eleventh shock was given during the initial 10 min. period, although it is difficult to determine this fact from the original study. Third, it is also difficult to assess the exact type of shock delivery procedure that was applied. As mentioned previously, it is important that the shock delivery procedure be specified for its effects may be radically different under the two types of delivery schedules. Nominally it appears that Kovach and Hess (1963) used non-contingent aversive stimulation (based on time); a closer examination of their data, however, reveals that effectively, the aversive stimulation was delivered on a contingent basis. In the case of one shock group, for example, subjects followed the imprinting stimulus for a total of 33 feet (approximately) out of a maximum total of 40 feet. Therefore, there would have been few times that the subjects would have received shock while they were not following the stimulus; functionally, then, the shock appears to have been delivered on a response contingent basis. The authors, then, should have specified which particular type of shock delivery schedule they believed they were using in order that readers could clearly interpret the results; a more detailed examination of this point will be dealt with later.[3] Fourth, it might also be noted that no attempt was made to assess the effects of the aversive stimulation after the imprinting session had been completed. Subjects were given no post-training trials to assess the effects of the shock on their later following tendencies; it may very well be the case that the effects of the shock treatment were only restricted to the training session and produced no demonstrable difference in later following behaviour. Given that imprinting experiments usually entail a post-training test (Bateson, 1966), it is difficult to assess if the shock had a permanent effect on the subject's imprinting experience or had only a temporary effect on its behaviour.

A more serious problem concerns the abstract of the study by Kovach and Hess (1963), however, for it is not an accurate description of the data that was obtained. In the abstract they state:

> Experimental subjects followed significantly more than controls at 14 and 18 hrs. if the shocks were either strong but infrequent, or relatively weak but much more frequent. Older chicks, however, followed significantly less under these two shock conditions. Strong and frequent shocks did not affect the amount of following in subjects at 14 hrs., but seriously interfered with it at all later ages. (p.461)

A closer examination of the data in the article, however, is only in partial agreement with these statements. As shown in Table 1, there is no case where weak but frequent shock (27 - 1 ma) produced a significantly greater following response. Furthermore, in reference to their statement that strong and frequent shock (27 - 3 ma) seriously interfered with following at all ages later than 14 hrs., only in one case (32 hrs.: 27 - 3 ma) were the results significant. At 18 hrs. the decrease in following was not significant and at 48 hrs. the subjects were not tested. Indeed, the only clearcut results are those found for the infrequent-heavy (11 - 3 ma) shock group. In this case, the delivery of a low number of high intensity shocks did appear to increase following behaviour at 14 and 18 hrs. but not at 32 or 48 hrs. of age.

In summary, then, in the case of chicks exposed to an imprinting stimulus at 14 or 18 hrs. of age, it appears that high frequency, low or high intensity shock makes no significant difference in the amount of following behaviour. The delivery of a low number of high intensity shocks (11 - 3 ma), however, does lead to an increase in following behaviour. The results that are specified in the abstract, therefore,

Table 1

Results of the Study by Kovach and Hess (1963)

Group	Results as reported in the abstract	Results as reported in the article
Experiment 1		
18 hrs.:		
11 - 3 ma	sig. increase	sig. increase
32 hrs.:		
11 - 3 ma	sig. decrease	sig. decrease
48 hrs.:		
11 - 3 ma	sig. decrease	not sig.
Experiment 2		
14 hrs.:		
11 - 3 ma	sig. increase	sig. increase
27 - 1 ma	sig. increase	not. sig.
27 - 3 ma	not sig.	not sig.
18 hrs.:		
11 - 3 ma	sig. increase	sig. (?) increase
27 - 1 ma	sig. increase	not sig.
27 - 3 ma	sig. (?) decrease	not sig.
32 hrs.:		
11 - 3 ma	sig. decrease	sig. (?) decrease
27 - 1 ma	sig. decrease	not sig.
27 - 3 ma	sig. (?) decrease	sig. decrease

require careful examination and are not as definitive as the authors would have readers believe. Nevertheless, as previously mentioned, many authors, perhaps relying on the abstract, cite this study as evidence that aversive stimulation, in general, facilitates imprinting.

Unfortunately, only one other study deals specifically with the effects of an aversive stimulus during the acquisition of imprinting. Barrett (1972) investigated the effects of response independent shock on the formation of an attachment response in Peking ducklings (Anas platyrhynchos). He presented four 18 to 20 hrs. old ducklings with ten 60 sec. successive presentations of two visual stimuli. During the five presentations of one of the stimuli, shock (1 ma, .3 sec., every 10 sec.) was delivered. A choice test was then given two hrs. after the last shock session and twice on the following day. Throughout the three test sessions, the ducklings spent less time with the stimulus paired with shock.

These results are not in agreement with those reported by Kovach and Hess (1963). Nevertheless, there are important differences which make it difficult to compare the two studies directly. First, the two procedures differ substantially. The study by Barrett (1972) was a discrimination learning task in which one of two stimuli was paired with shock and a preference test was given sometime later. Furthermore, in his study the subjects were given frequent, low intensity shock throughout a number of trials (30 one ma shocks distributed evenly among 5 trials). In the study by Kovach and Hess (1963), however, only one stimulus was presented and the effects of shock on the subject's following behaviour were assessed at the time of this single presentation. In addition Kovach and Hess (1963) found significant results only with low frequency, high intensity aversive stimulation. Also, different species were used in the two studies; Barrett (1972) used ducklings as subjects in his study whereas Kovach and Hess (1963) used domestic chicks. It is difficult to compare studies in which different species have been used in different experimental paradigms. In summary then, the results of the two studies using non-contingent aversive stimulation during the acquisition of imprinting are not in agreement. Because of a number of procedural differences, however, it is impossible to determine where the source of the discrepant findings may lie.

A similar uncertainty exists with respect to the effects of response contingent aversive stimulation in the imprinting situation. To date, there have been no studies specifically dealing with this area of investigation. However, there have been two studies (Fischer & Gilman, 1969; Pitz & Ross, 1961) that have dealt with the presentation of high intensity sounds during the acquisition of imprinting, but, as will be discussed below, it is difficult to assert that such stimulation is aversive to the subject. In their study, for example , Pitz & Ross presented one group of chicks with intense auditory stimulation (80 db) whenever the subjects approached within 6 in. of the moving stimulus object. The delivery of the loud tone, therefore, was made contingent upon the following response. A second group received the loud tone whenever the subjects were directly across from the stimulus object (contingent upon not following the stimulus) and a third group (control) received no aural stimulation. Each subject in each group received one 15 min. trial each day for five days. The authors found that intense auditory stimulation applied when the subjects were in close proximity to the stimulus object significantly increased the following response of these animals over the five day testing period. It also appears that the loud tone enhanced the following response during acquisition, for during the first testing session (12 to 15 hrs. after hatching) the group that received the intense auditory stimulation while close to the stimulus object followed significantly more than did the other two groups. No differences between the other two groups were found.

As previously mentioned, however, it is difficult to assert that such intense auditory stimulation is aversive to a subject when, in fact, the application of this tone increased following behaviour when the sound was made contingent upon this response and no other behavioural indices of the "aversiveness" of the tone were provided.[4] Furthermore, Fischer and Gilman (1969) found that even with intensities of sound high enough to be considered painful to human ears (95 db) chicks rarely displayed active avoidance responses. Indeed, Evans (1975) reports that the louder the auditory stimulation, the greater the decrease in distress vocalizations by young domestic chicks (within the levels used in his study: 65, 75, and 85 db). Furthermore, auditory stimuli *per se*, are considered one of the most potent elicitors of following (Gottlieb, 1963, 1965; Gottlieb & Klopfer, 1962; Smith & Bird, 1963). Therefore, no evidence exists to date which implicates auditory stimuli as an aversive stimulus for chicks in the imprinting situation. Thus, it is necessary to exclude those few studies in which the effects of loud tones on the following response were investigated.

In summary, then, there is little information concerning the effects of aversive stimulation on the acquisition of imprinting. In the case of non-contingent aversive stimulation, what information there is, is equivocal. In one study (Kovach & Hess, 1963) an increase in following behaviour was reported while in the other study (Barrett, 1972) a decrease in approach behaviour was found. In the case of response contingent aversive stimulation, however, there is simply no information. Therefore, there appears to be little basis on which Hess (1973) can continue to claim that aversive stimulation facilitates imprinting. Fortunately, this lack of information is not the case for subjects that have previously been imprinted to a stimulus; the effects of aversive stimulation in this situation have been well established.

In a recent series of experiments by Barrett et al. (1971), for example, the effects of both types of shock delivery on the following response of imprinted ducklings were investigated. The subjects were imprinted to a moving stimulus 1 hr. a day for a period of 4 days. On the fifth day the subjects received 2 min. of shock-free exposure to the imprinting stimulus followed by 5 min. of exposure to response independent shock. The response independent shock condition was applied every 30 sec. regardless of the subject's behaviour at the time of presentation. Each subject was then assigned to one of three conditions: either the subject remained in the same response independent shock group or the subject was assigned either to a response contingent shock group or a no-shock group. Each of these three conditions lasted 10 min.

The effect of imposing the response independent shock on base-line following was to increase the rate at which the ducklings followed the stimulus. A second experiment in this same study (Barrett et al., 1971) also showed that even high rates of response independent shock (15 shocks per min.) did not suppress the following response. In the case of the response dependent shock, however, an opposite effect was found. In the case of this group, response contingent shock was delivered to the imprinted subject whenever it crossed the center of the apparatus while in the act of following the stimulus object. There was a significant reduction in the amount of time that imprinted subjects spent following the stimulus. The effect was not permanent, however, and recovery was relatively rapid when the following response was no longer punished. Similar response suppression in punishment situations has been reported in other experiments (Barrett, 1972; Hoffman, Stratton, & Newby, 1969). In summary, then, it appears that punishment will reduce the rate at which a previously imprinted subject will follow the imprinting object while response independent shock may actually increase the rate of this same behaviour.

Similar results have also been reported in other studies that have investigated the effects of aversive stimulation on attachment behaviour. Scott (1962), for example, reported a study in which puppies were reared in isolated units throughout their entire socialization period but were permitted regular contacts with the experimenter. During these times one group of puppies was always treated in a kind manner, a second group was always punished for any positive approach to the experimenter, while a third group "was sometimes rewarded and sometimes punished, but in a purely random way" (Scott, 1962, p.950).

Scott reported that puppies which received constant punishment showed the least amount of attraction and dependency behaviour while the subjects that were both rewarded and punished showed the most. While it would be difficult to assert that the non-contingent aversive stimulation resulted in the increase in attachment behaviour it does appear that the response contingent punishment decreased the response rate of the same behaviour.

Studies investigating the effects of aversive stimulation on other "instinctive" behaviours have also reported similar results. Myer (1966), for example, has studied the effects of response contingent aversive stimulation on the mouse-killing behaviour of rats. Twelve rats which had a previous history of attacking and killing mice, were each presented one mouse a day for five days. When the rat first attacked the mouse it received one 3 sec. shock (1.5 ma). Myer (1966) found that this punishment had a marked suppressive effect on the mouse-killing by that rats. The suppressive effects were so great, in fact, that nine of the rats required a considerable period of time (29 - 58 days) before they returned to their pre-shock level of mouse-killing.

Similar response suppression in other species has also been found in studies investigating the effects of punishment on other "instinctive" behaviours. Melvin and Ervey (1973), for example, permitted Siamese fighting fish (Betta splendens) to direct aggressive displays (gill extensions) towards a mirror either 15 or 45 times. Following these trials, the subjects were shocked for such displays. Intense shock punishment led to a complete suppression of the gill extension. Other authors report "long-lasting response suppression" (Walters &

Glazer, 1971, p.331) when the digging responses of Mongolian gerbils (Meriones unguiculatus) were punished. In general, then, it would appear that response dependent aversive stimulation may decrease the response rate of the punished behaviour for certain "instinctive" behaviours.

Studies have also shown that non-contingent aversive stimulation may serve to increase the response rate of some "instinctive" behaviours (Azrin, Hutchinson, & Sallery, 1964; Reynierse, 1971; Ulrich & Azrin, 1962). Ulrich and Azrin (1962), for example, demonstrated that when two rats placed in the same experimental chamber were given non-contingent shock, fighting increased between the two animals. A study by Myer and Baenninger (1966) has also shown that the application of non-contingent aversive stimulation may also increase the response rate of an "instinctive" behaviour after that behaviour had previously been suppressed by punishment. In general then, it appears that non-contingent shock may serve to increase the response rate of specific "instinctive" behaviours.

It is evident from the above examples, then, that the performance of subjects under conditions of response contingent punishment may be different from subjects under conditions of non-contingent aversive stimulation. In studies involving "instinctive" behaviours, including studies of previously imprinted subjects, it appears that response contingent aversive stimulation decreases the response rate of the punished behaviour while in response independent situations, facilitation of a particular response may occur. Furthermore, these results are generally consistent with results found in studies of learning. In learning situations it has been shown that there will be greater suppression of a response if shock is made contingent upon a response than if the aversive stimulus is not contingent upon the response (cf., Church, 1963; Solomon, 1964). Furthermore, once a subject has been punished "the mere presentation of stimuli associated with an aversive stimulus may serve to suppress responding" (Church, 1963, p.380). In response independent situations, however, the behaviour of a subject may be more variable and uncertain. In different situations, response facilitation or response suppression can occur depending in part on the nature of the response in question, the species, and the parameters of the aversive stimulation (cf., Fowler, 1971; Myer, 1971; Solomon, 1964). Nevertheless, the results of studies investigating the effects of aversive stimulation on "instinctive" behaviours are consistent with the results found in learning situation. In summary, different effects on a behavioural response may be obtained depending on the type of shock delivery schedule that is used.

As previously mentioned, however, there may be some difficulty in distinguishing between the two types of shock delivery procedures in the imprinting situation. In an imprinting experiment shock may be applied whenever the subject approaches or follows the stimulus in the response contingent situation, for example, or it may be given on a time-basis in the response independent situation. If the imprinting stimulus is effective in eliciting approach or following behaviour, however, there may be few times when the subject is not engaged in one of these behaviours. Nominally, therefore, there may be two different types of shock delivery procedures but effectively, both types may be examples of response contingent situations. If no differences between the two types were found, the question remains whether this result is a true reflection of the situation or whether it is a result of possible confounding. In the imprinting situation, then, it would appear difficult to arrive at a truly response independent procedure.

In summary, the effects of response independent aversive stimulation during the acquisition of imprinting are uncertain. Only two studies have been conducted: the first (Kovach & Hess, 1963) appears to be inadequate, while the second (Barrett, 1972) yielded results that contradicted the first. Furthermore, an analysis of the imprinting situation suggests that since a high rate of following is observed, a truly response (following) independent shock schedule may be very difficult to implement. On the other hand, while the effects of response dependent aversive stimulation applied during the acquisition of imprinting are unknown, the implementation of such an investigation would be straightforward. Moreover, since Hess (1973) has continued to maintain first, that aversive stimulation facilitates imprinting, and second, that an imprinting/learning distinction is based, in part, on the different effects of aversive stimulation in the two experimental paradigms, it is necessary to evaluate the effects of aversive stimulation on imprinting. Therefore, the purpose of this study was to assess the effects of response contingent aversive stimulation during the acquisition of imprinting.

Method

Subjects

For each of the four experiments, 60 Cobb chick eggs were obtained from the Carleton Hatcheries located in Ste. Adolfe, Manitoba. The eggs were picked up on the 18th day of incubation and transported to the University of Manitoba where they were placed in a communal hatcher. The temperature of the hatcher was approximately 37.5^{0}C (99.5^{0}F) and a high humidity level was maintained by placing a large pan of water within the hatcher unit. Four red light bulbs (60W each) provided the source of heat for the hatcher and were switched on automatically when heat was required.

On approximately the 20th day of incubation, a period of surveillance began in order to record the hatch time of the first subject. Thereafter, the hatcher was checked every 4 hours and the number of subjects hatched during this period was recorded. A subject was considered hatched when it had separated itself from the egg shell and the products associated with it, without any assistance from the experimenter. The approximate time of hatch, determined by visual inspection of the subject, was also recorded. A subject's age could thus be estimated within an error of $\pm$ 1 hr. Subjects were then removed in the dark from the hatcher and placed in individual holding cages.

Rearing Conditions

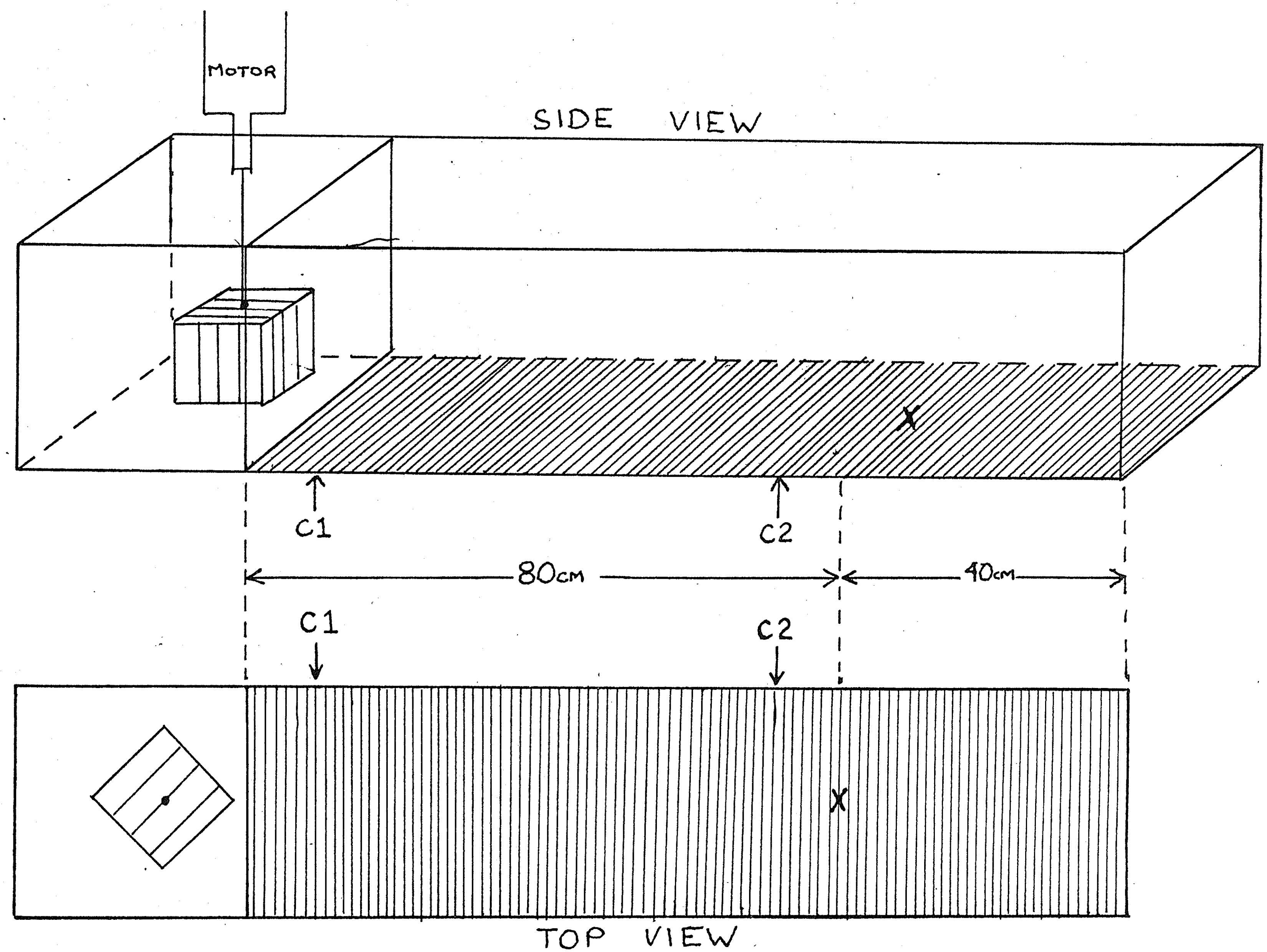
Subjects were assigned to individual cages measuring 24 X 22 X 21 cm. The room in which the cages were housed was maintained at a temperature of approximately 33^{0} C (91.4^{0}F) and the room lights were kept turned on except when the experimenter was working in front of the cages. During these times, the lights were turned off; then, the only source of illumination was a lamp containing a red 40 watt light bulb directed towards one corner of the room. Housing the subjects individually prevented physical and visual contact among them. As the subjects were raised in the light, however, they did have an opportunity to see and possibly form an attachment to their cage and a small portion of the room in front of the cage. Previous pilot work, however, had indicated that subjects raised in the light perform better in the imprinting situation. Also, subjects were not raised in auditory isolation; thus, in addition to their own sounds, the subjects were exposed to the sounds of their brood mates as well as any other sounds associated with the experimenter's movements in the room. Subjects placed in the individual cages had access to a continuous supply of food (Chick Starter) and water.

Apparatus

Training apparatus. As shown in Figure 1, the training apparatus was a straight runway with an imprinting stimulus at one end. The two sides of the apparatus, each measuring 121 X 30.5 cm, were made from opaque white polypropylene. Polypropylene was used in order that diffuse light from the outside could be used to illuminate the interior of the runway. Along one length of each of the two sides, holes were drilled 1.5 cm from the bottom edge and at 1 cm intervals. Stainless steel rods were then inserted into each of the holes joining the two sides. The rods thus served as a floor for the apparatus; a total of 120 rods were used. The 80 rods that were closest to the stimulus compartment at one end of the runway were wired in series and connected to

Figure 1

Figure 1. A side and top view of the training apparatus. The X represents the initial placement location of the subject. This drawing is for illustration purposes only and does not include all details of the actual training apparatus.


MOTOR
SIDE VIEW
X
C1
C2
80cm
40cm
C1
C2
X
TOP VIEW

a Grason Stadler Shock Generator (model E1064GS). The rods at the far end of the apparatus, therefore, could not be energized. Shock was chosen as the aversive stimulus for several reasons. First, shock is one of the easiest stimuli to measure and control (Church, 1963, 1969). Second, through the use of shock, it would appear that the aversive contingency has been met in the sense that shock is able to maintain escape and avoidance responses (Fowler, 1971). Third, shock was chosen in order to make the present study more comparable with previously reported studies involving aversive stimuli in the imprinting situation.

The stimulus compartment, located at the end of the runway, was made from polypropylene and measured 18 X 26.5 X 30.5 cm. Separating the stimulus compartment from the runway was a piece of clear plexiglas measuring 26.5 cm wide X 18 cm high, on top of which was a piece of plywood 26.5 X 12.5 cm. The plexiglas provided a view of the stimulus object from the inside of the runway while the plywood prevented direct visual contact with the source of light. Four white Christmas lights (Noma brand - 10 watt bulbs), located behind the plywood in the stimulus compartment, were used to illuminate the imprinting object. These lights were part of two strings of white Christmas lights each containing 14 bulbs. The rest of one string (12 bulbs) ran the outside length of the apparatus approximately 10 cm from the plexiglas on one side while the other string was situated in the same position on the opposite side. This source of diffuse lighting proved to be sufficient to illuminate the entire length of the apparatus.

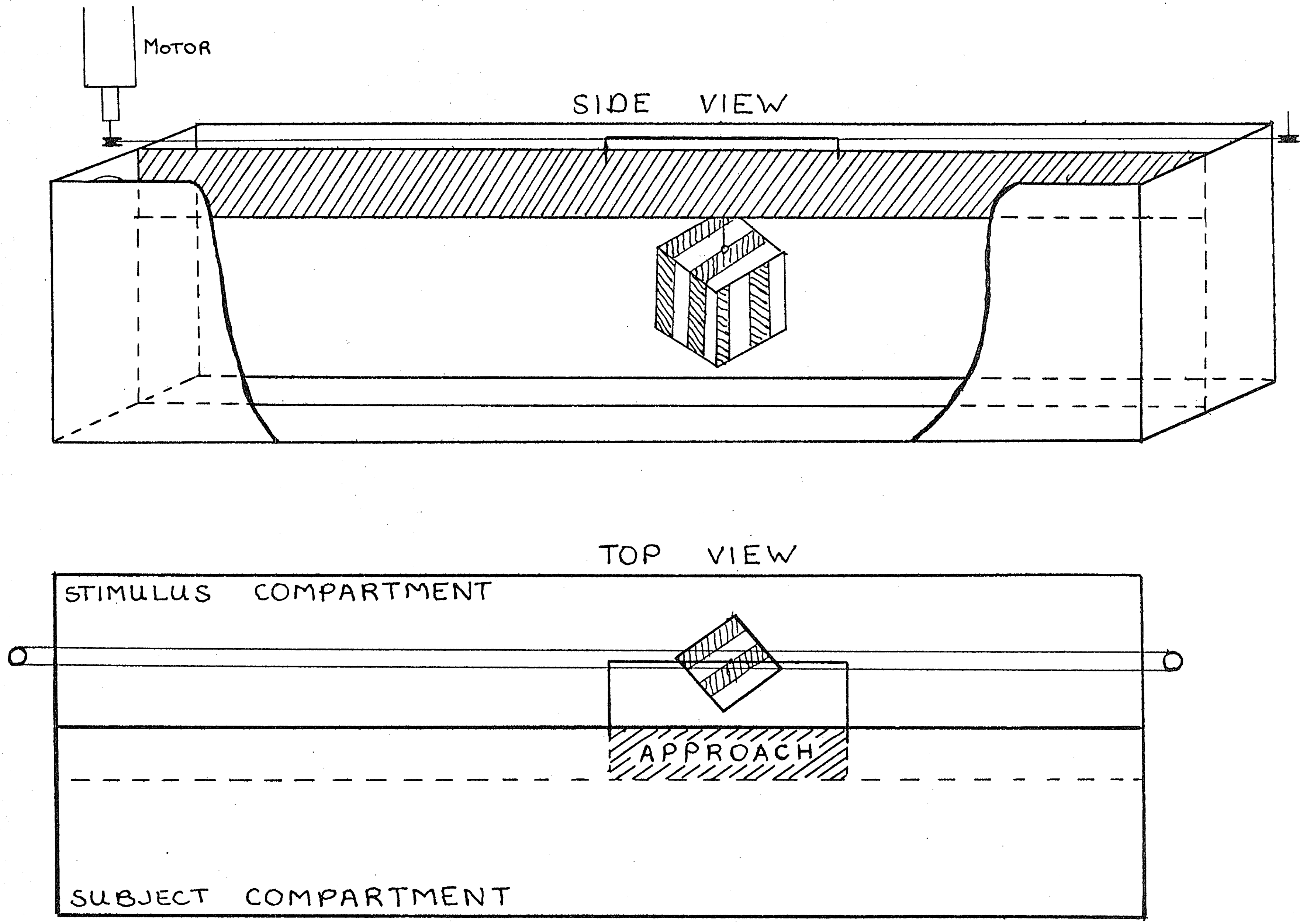
A wooden cube measuring 10 cm on each side and painted alternate red and blue vertical stripes 2 cm wide, was used as the imprinting stimulus. The colour and size of the imprinting object were chosen as these parameters have been shown to be effective in eliciting approach responses (Fischer, Morris, & Ruhsam, 1975; Gray, 1961; Hess, 1956, 1959; Kovach, 1971a; Salzen, Lily, & McKeown, 1971; Schulman et al., 1970; Smith & Bird, 1964; Smith & Hoyes, 1961; Taylor, Sluckin, & Hewitt, 1969). The cube was suspended approximately 3 cm above the floor of the compartment by means of a thin thread attached to a motor (Hurst Synchronous Motor model CA - 2 RPM) which was located above the end compartment. The cube could then be rotated at a speed of 2 RPM; rotation of the stimulus object has also been shown to facilitate approach responses (Bateson, 1966; Gossup, 1974; Smith, 1969; Thompson & Dubanski, 1964). Only the stimulus and a small portion of the thread attached to it were visible from the interior of the training apparatus; all other connections, screw eyes, and various switches could not be seen from this location.

In addition, the seventh rod from the stimulus compartment, 7.5 cm from the plexiglas, was marked with white tape on the outside of the apparatus. As will be explained later, this distance was used to define approach responses as well as one of the shock areas. A second shock area was also marked by means of white tape located 72.5 cm from the stimulus compartment.

Testing apparatus. The testing apparatus, shown in Figure 2, measured 121 X 30.5 X 29 cm. The floor, the two ends, and one wall were made from 3/4 in. plywood painted with a white gloss enamel. The other wall was made from plexiglas 120 X 17.5 cm, above which a piece of plywood, 120 X 11.5 cm, was placed. The plexiglas provided a view

Figure 2

Figure 2. A side and top view of the testing apparatus. The area marked "APPROACH" moved with the stimulus object. This drawing is for illustration purposes only and does not include all details of the actual testing apparatus.


MOTOR
SIDE VIEW
TOP VIEW
STIMULUS COMPARTMENT
APPROACH
SUBJECT COMPARTMENT

of the stimulus object which was located on the outside of the testing apparatus approximately 3 cm from the plexiglas. A string of white Christmas lights suspended from the outside of the plywood provided a source of illumination for the stimulus. A constant white background was also provided behind the stimulus object by painting the wall, the floor, and the two ends of the stimulus compartment with white gloss enamel.

The test stimulus was the same stimulus used in the training apparatus. During the testing phase, however, the stimulus moved along the length of the test apparatus. The stimulus was suspended approximately 3 cm above the floor by means of a thin line attached to a nylon runner wheel. The wheel, in turn, was hooked onto a curtain rod, 120 cm long, which was positioned a little above the stimulus object. This runner wheel was also attached to a fishing line suspended between two pulleys which were located a little above and to the side of the curtain rod ends. A 72 RPM motor (Slo-Syn Driving Motor model SS-150RC) drove one of the pulleys which in turn moved the fishing line. The stimulus object thus moved back and forth along the curtain rod, parallel to the plexiglas, at a speed of approximately 7.5 cm/sec. The motion of the stimulus object was not entirely smooth, however; in addition to the movement along the length of the apparatus there was also a slight jerky motion associated with the movement of the nylon runner wheel. Only the stimulus object and a small portion of the thin line attached to it were visible from the interior of the apparatus.

A distance of 7.5 cm from opposing ends of the stimulus object was marked by means of pipe cleaners attached to the pulley and extending on either side of the cube. A light pencil line 7.5 cm from the interior side of the plexiglas and extending the length of the apparatus was also drawn on the floor. A rectangular area, 29.5 X 7.5 cm, which moved with the test object, could thus be estimated.[5]

Monitoring the subject's position and behaviour was made possible in both the training and testing situations by placing a mirror above both runways. Such a system has been used successfully by other experimenters (Bateson & Jaeckel, 1974; Gottlieb, 1961, 1968) and the subjects do not attend to the mirror or give any other indications of its presence.

As has been noted, two runways were built having similar dimensions but differing in design. The reason for having a different training and testing apparatus was to ensure that in the testing situation, the shock was paired only with the imprinted stimulus and not with other associated cues in the original training apparatus. Experimenters have shown that an apparatus similar to one in which shock has been presented may suppress behaviour in later testing situations (Amsel, 1950; Amsel & Cole, 1953; Myer, 1971).

Procedure

Training. The purpose of the training procedure was to provide an opportunity for the chick to form an attachment to the imprinting stimulus. The procedure also provided a concurrent measure of the effects of the aversive stimulation.

When a subject was to be trained, it was removed from its cage, placed into a transport box, and carried into the testing room. The testing room was maintained at a temperature of 21°C (70°F). Although this temperature was cooler than the room in which the subjects were housed, Fischer (1970) has shown that in the imprinting situation, subjects taken from a warmer to a colder room display greater following behaviour. The room lights were also turned off throughout all trials with the exception that small lights on a relay panel provided enough illumination for the experimenter to find his way about the room. Inside the room the subject was removed from the transport box and placed in the training apparatus 80 cm from the stimulus compartment. The stimulus was not visible at the time of subject placement as the lights in the stimulus compartment and along the runway were turned off. The cube was rotating, however.

When the training session began, the apparatus lights were turned on and two timers associated with the beginning of the session were started. One timer (Singer Running Time Meter) recorded the five min. trial period. During this five min. period the stimulus was continuously visible unless the subject approached within 7.5 cm of the stimulus object (as marked by the white tape on the 7th rod from the end). This distance of 7.5 cm was chosen as the definition of an approach response as it has been used in other studies of imprinting (Kovach, 1971a, 1971b; Kovach, Callies, & Hartzell, 1969). If the subject approached within 7.5 cm of the stimulus object during the five min. trial it was considered a "responder". The lights associated with the start of the trial were then turned off. A second timer (Grason Stadler Time Meter) measured the time taken by each responder to approach within the required distance of the stimulus compartment (ie, its latency-to-first approach). If a subject did not approach the stimulus within the five min. trial time limit, however, the subject was considered a "non-responder" and was discarded. It was not used again in the experiment.

If a subject responded on the first trial, four additional trials with a limit of three min. each, were then run. While the lights were off, the subject was retrieved and replaced at the original start position (80 cm from the plexiglas). Although no attempt was made to control the intertrial interval precisely, this period never exceeded 4 seconds for any subject. The three min. trial timer and another timer measuring the subject's latency-to-approach were started when the lights associated with the stimulus presentation were turned on. Once again, the subject had to approach within 7.5 cm of the stimulus object before the end of the three min. trial for an approach response to be recorded. The subject's latency time was then recorded; if a subject failed to reach the designated distance, however, a score of 180 sec. was assigned. The subject was then retrieved and replaced at the start position for the next trial. A similar procedure was followed during the following trials. In addition, during these 4 three-min. trials (Trials 2 - 5), a shock/no shock condition applied that will be discussed shortly.

At the end of the five trials, the apparatus lights were turned off, all latency scores were recorded, and all timers were reset. The subject was retrieved and returned to its cage and the next subject was chosen.

Prior to the training procedures, a subject was assigned to one of three shock treatment groups, or to one of three control (no shock) groups. One shock treatment group (group C1) was defined in terms of the subject's motor responses directed toward the imprinting stimulus.

If a subject in this group approached within 7.5 cm of the imprinting stimulus (ie, moved a distance of 72.5 cm from its original placement position), it received a shock applied manually by the experimenter. Shock in treatment group C1, then, was made contingent upon the subject's approach responses. The second shock treatment group (group C2) was also defined in terms of the subject's motor responses directed toward the imprinting stimulus. If a subject in this treatment group moved a distance of 7.5 cm toward the imprinting stimulus, it then received the aversive stimulation. Thus shock in treatment group C2 was made contingent upon the subject moving toward the stimulus, but these subjects (group C2) only had to advance 7.5 cm from the original placement position before receiving the shock. Group C2 was included in the experimental design in order to determine if there was a differential effect in the behaviour of the subject by applying contingent shock distant from, rather than close to, the start position. A third treatment group (group NC) did not depend on the behaviour of the subjects for the delivery of the aversive stimulation. If a subject responded on the first trial, it was then placed manually in a smaller "outside" apparatus (measuring 23 X 11 X 28 cm) and given shock through a floor grid. During the application of the shock, the subject was not handled. It was then retrieved and placed again in the original training apparatus at the start position. This entire procedure was followed prior to the start of Trials 2 - 5 for each subject in the NC group whether or not the subject made any response toward the stimulus object in the imprinting apparatus (with the exception of Trial 1). No attempt was made to control for the longer time interval between trials that this procedure took (in the order of a few seconds). This group (group NC) was run in order to control for the possible energizing effect that shock may have had for subjects in the other two contingent groups. In addition, within each shock treatment group a subject was also assigned to one of three levels of shock intensity: 1, 2, or 3 ma; all shock levels were applied for ½ sec. duration. Therefore, in total, there were nine shock treatment conditions.

As mentioned previously, control groups were also used. Subjects assigned to a control group received exactly the same treatment as did subjects in one of the three shock treatment groups with the exception that the shock generator was not connected to the floor grids. Thus, one group of control subjects (group C - C1) had to advance within 7.5 cm of the stimulus compartment before the shock generator was activated; a second group of control subjects (group C - C2) had to advance only 7.5 cm toward the stimulus before the shock apparatus was operated; while the third group (group C - NC) was placed in the outside apparatus, prior to the start of the next trial, before the generator was operated. The control subjects received no shock, however; only the sound of the generator was activated. Otherwise, the control groups received exactly the same treatment as did subjects in the shock treatment groups.

The sequence for running all subjects, determined by random selection, was as follows: the first responder was assigned to group C2/1ma; the second responder was assigned to group C2/2ma; the third to group C1/1ma; the fourth to group NC/3ma; the fifth to C1/3ma; the sixth to C1/2ma; the seventh to NC/1ma; the eighth to C2/3ma; the ninth to group NC/2ma; and the tenth to the control group. Because of a lack of available subjects, only one in every ten subjects was a control subject. Therefore, it took 30 responders before each of the three control conditions was occupied by a subject. The sequence for running the control subjects was as follows: the first control subject was assigned to group C - C2; the second to group C - C1; and the third to group C - NC.

As previously mentioned, only first trial responders were used; if a non-responder occurred within the above sequence, it was discarded and its position filled by the next subject. Also, as a chick's feet are fairly resistant to shock, all subjects in all groups had their feet placed in water at the start of the first and third trial before they were placed in the training apparatus.

The age of the subjects was between 10 and 16 hrs. (post-hatch) when they were used in the training session. This age range was chosen as it has been shown to be the optimal period for subjects to form an attachment to a stimulus (Bateson, 1966; Hess, 1964, 1973; Smith, 1969). After a responder had undergone the training trials, it was returned to its respective cage and left for 24 hrs.

Testing. After the 24 hrs. period had elapsed, each subject that had completed the training session was run for a 5 min. testing period. A subject was retrieved, placed into a transport box, and carried into the testing room. The room was dark and all equipment was off at this time. The temperature of the testing room was approximately 21^{O}C (70^{O}F).

The stimulus used in the training procedure was positioned halfway between the two ends of the stimulus compartment. Once the chick was placed at one end of the test apparatus, the lights were turned on and the motor connected to the stimulus object was started. The stimulus then began to move away from the subject. At the beginning of the trial, two timers were also started. One timer (Singer Running Time Meter) recorded the 5 min. testing period at the end of which an auditory signal sounded that indicated to the experimenter when the session was over. The second timer (Grason Stadler Time Meter), operated manually by the experimenter, recorded the subject's latency to approach the stimulus object. The rectangular area, defined earlier, was used to determine an approach response. A third timer (Grason Stadler Time Meter), also operated manually, recorded the amount of time that a subject spent in the defined area. This time constituted the subject's stay-near score. At the end of the test period, both times were recorded and both timers were reset. The subject was then returned to its cage and the next subject was chosen. The testing procedure was the same for all subjects except that alternate subjects were placed at opposite ends of the test apparatus.

Replications. Three replications of this study were conducted in order to ensure that an adequate sample size was tested. A total of 12 subjects were run in each of the nine shock groups and four subjects were run in each of the three control conditions. Therefore, a total of 120 subjects were used. The training and the testing sessions were exactly the same for all four experiments.

Results

Training Data: Trial 1

Approximately seventy percent (70%) of the subjects that hatched approached the stimulus object during Trial 1 and thus were considered responders. Only the data from the responders were used in the following analyses.

During Trial 1 all subjects were treated in a similar manner, that is, no experimental manipulations were performed on the subjects before or during the first trial. Therefore, this trial was considered separately from the other training trials and a two-way analysis of variance was performed on the data to determine if there were any initial differences in the latency scores of the subjects. As shown in Table 2, there were no significant differences in the scores of the subjects placed in the various groups ($p > .05$). Therefore, the performance of subjects in any particular group during Trial 1 did not differ significantly from the performance of subjects in any other group.

Training Data: Trials 2 - 5

The latency scores of each group for the next four trials during which the experimental conditions were applied, were then analyzed. A three-way analysis of variance with repeated measures on one factor was used to analyze the data. Trials was the repeated measure because the same subjects were used in each of the four successive trials.

Prior to conducting the experiment the problem of error rates was considered. It was decided that the two independent factors, labelled group (where the subjects received the shock) and shock (the intensity of the aversive stimulation) in Table 3, and the interaction term (group x shock) would have an overall error rate set at the .03 level. Applying Dunn's procedure (cf. Kirk, 1968), then, each of these sources of variation had its probability level set at .01 (.03/3). Those comparisons involving the repeated factor (labelled trials and the 3 inter-

Table 2

Analysis of Variance Summary Table - Trial One

Source	SS	df	MS	F
Group	677.233	2	338.627	0.06
Shock	3346.493	3	1115.498	0.19
Grp x Shk	7671.106	6	1278.518	0.21
Error	646091.125	108	5982.324	

Note. With all F values less than 1.00, no probability values were calculated.

Table 3

Analysis of Variance Summary Table - Training Data

Source	SS	df	MS	F	p exc.
Groups	19603.25	2	9801.625	2.914	0.059
Shock	69633.06	3	23211.020	6.901	0.001
Linear	67909.80	1	67909.800	20.189	0.001
Dep. from Lin.	1723.26	2	861.631	0.256	-
Grp x Shk	13088.50	6	2181.417	0.649	0.691
Error	363273.75	108	3363.646		
Trials	4795.31	3	1598.438	1.587	0.192
Trls x Grps	3339.06	6	556.510	0.553	0.768
Trls x Shk	16956.69	9	1884.076	1.871	0.056
Trls x Grp x Shk	16429.69	18	912.760	0.906	0.571
Error	326352.44	324	1007.261		

actions involving trials as a factor) had an overall error rate set at .04; once again, each of the sources of variation had a value set at the .01 level. Therefore, the overall experimentwise (EW) error rate for Trials 2 - 5 was set equal to .07 (.03 + .04). Although this value may appear high, it is actually much more conservative then would be the case if each source of variation had been tested at the .05 level. Furthermore, with so little research in this area of imprinting, any attempt to decrease the overall EW error rate would have resulted in extremely low alpha values and the subsequent possibility of overlooking potential differences.

The analysis of variance indicated that there was a significant main effect attributable to shock intensity during the training period ($p < .001$). A trend analysis performed on this data indicated a significant linear component ($p < .001$); no other components (quadratic or cubic) were significant ($p > .05$). As can be seen in Figure 3, an increase in the intensity of the shock produced a corresponding increase in the latency time of the subjects. Tukey's Honestly Significant Difference (HSD) procedure further indicated that the 3 ma shock group took significantly longer to approach the stimulus than did the subjects in the 0 ma and the 1 ma shock groups ($p < .01$); evidence of this difference can be seen by comparing the shock intensity means seen in Table 4. There were no other significant differences with the shock condition.

No other significant main effects were obtained and there were no significant interaction terms even if the more liberal .05 level had been adopted. However, there is some evidence to indicate that differences

Figure 3

Figure 3. Latency scores (training data) plotted as a function of shock intensity. Within each level of shock intensity the group scores were collapsed since there were no significant differences between groups.

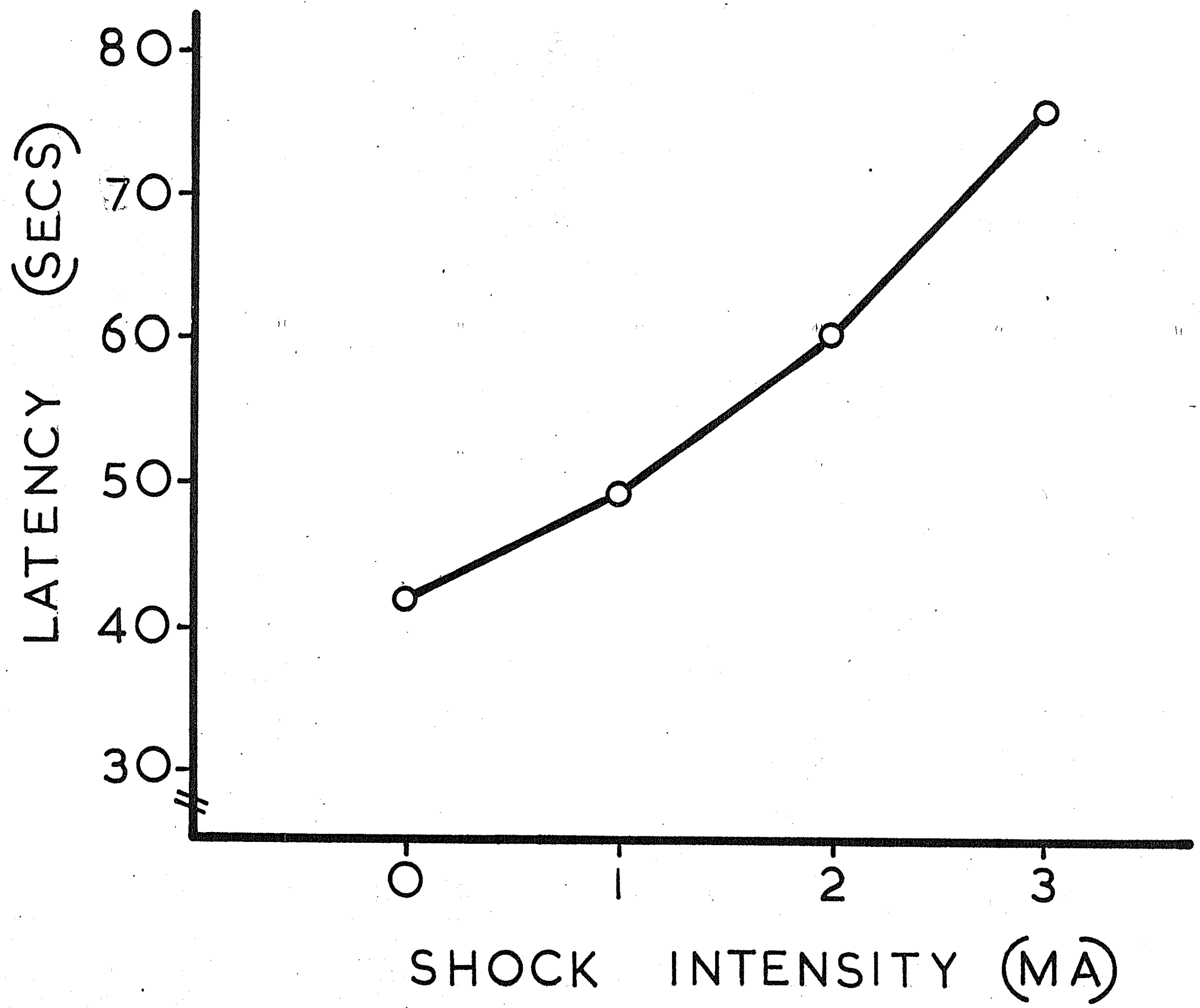

LATENCY (SECS)
80
70
60
50
40
30
0
1
2
3
SHOCK INTENSITY (MA)

Table 4

Mean Latency Time for the Groups x Shock Condition - Training Data

Group	Shock Intensity 0 ma	1 ma	2 ma	3 ma	Group Means
C1 (contingent)	39.31	56.08	56.50	82.75	58.66
C2 (contingent)	51.56	49.73	69.42	88.27	64.75
NC (outside shk)	34.94	41.96	55.44	57.29	47.41
Shock I. Means	41.94	49.26	60.45	76.10	

Note. All entries are in units of secs. and are averaged over Trials 2 - 5. The Shock I. Means are also the same figures that are plotted in Figure 3.

did exist among the three groups; as seen in the last column of Table 4, differences are evident among the three means ($p < .06$). In addition, as shown in Figure 4, there are some differences evident in the shock x trial interaction as well ($p < .06$). These differences, although they did not reach the significance level adopted for use in this study, will be discussed later.

The number of shocks that each experimental group received during the training trials varied. Although the NC group always received four shocks per subject, this condition was not the case for the two contingent shock groups. In these latter groups, a subject was not shocked if it did not approach the shock area prior to the end of the trial. The differences among the number of shocks given each group were minimal, however, and did not differ significantly from any other experimental group (Rank Test for Two Independent Samples, $p > .05$).

<u>Test Data</u>

A multivariate analysis of variance with two dependent measures (latency and stay-near times) was used to analyze the test data. As shown in Table 5, there were no significant main effects and no signnificant interaction term ($p > .05$). As shown in Table 6, the means for the latency times of all three groups were extremely close, while the differences between the means for the stay-near times were only slightly larger. In summary, during the test phase there were no significant differences among the groups in terms of the time to approach the stimulus or the amount of time spent near the stimulus object.

Figure 4

Figure 4. Latency scores for the shock X trial interaction. The three groups are combined within each of the 4 levels of shock intensity.

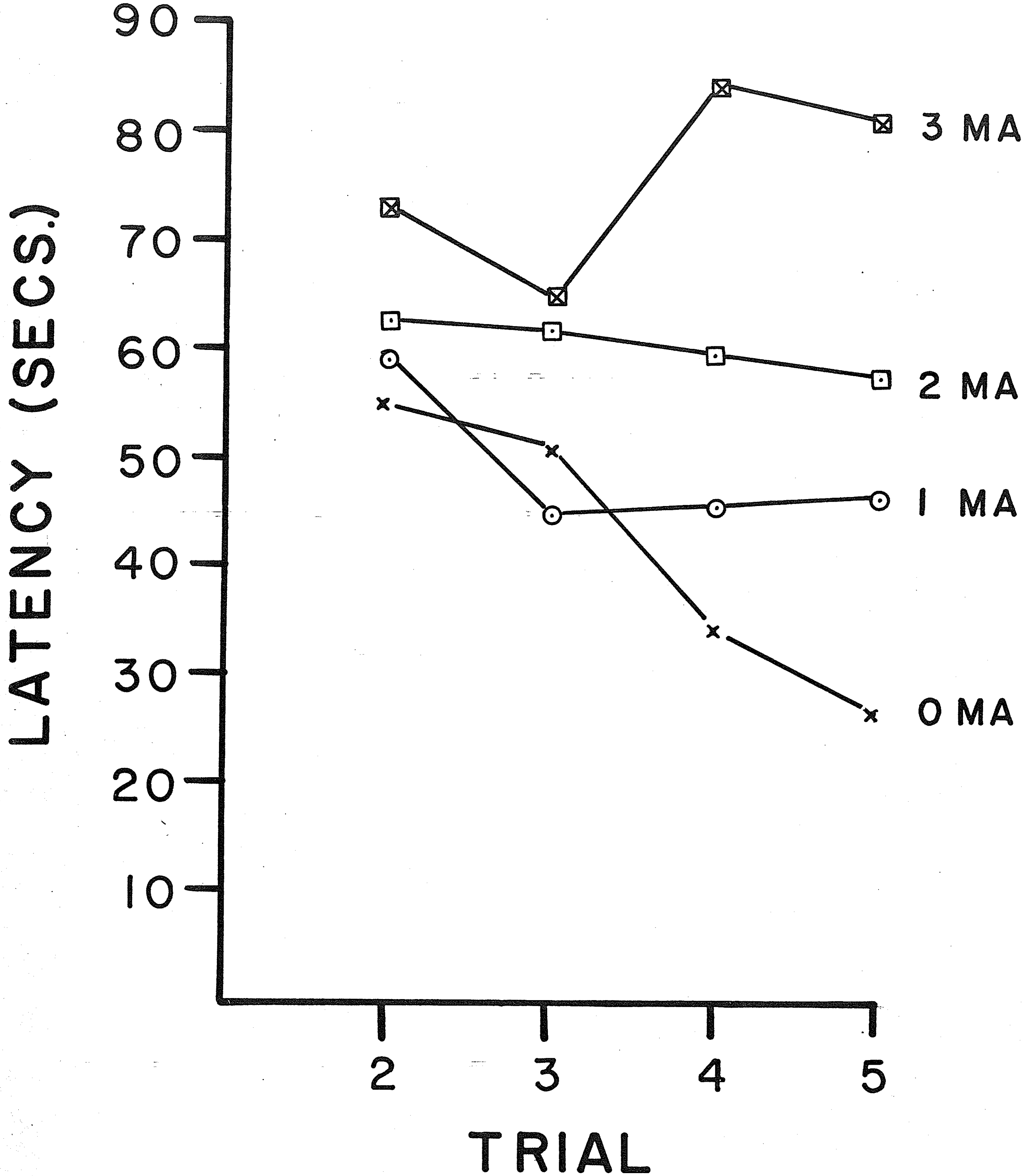

LATENCY (SECS.)
90
80
70
60
50
40
30
20
10
3 MA
2 MA
1 MA
0 MA
2
3
4
5
TRIAL

Table 5

Analysis of Variance Summary Table - Test Data[6]

Source	SS	df	MS	F	p exceeded
Group		4		1.621	0.170
Latency	114.869	2	57.435	0.024	0.977
Stay near	4701.629	2	2350.815	2.171	0.119
Shock		6		1.362	0.231
Latency	3035.568	3	1011.856	0.418	0.741
Stay near	7366.941	3	2455.647	2.268	0.085
Grp x Shk		12		1.284	0.230
Latency	12549.218	6	2091.536	0.864	0.524
Stay near	8159.531	6	1359.922	1.256	0.284
Error		216			
Latency		108	2421.159		
Stay near		108	1082.807		

Table 6

Test Data Means

Group	Dependent Measure: Latency	Dependent Measure: Following
C1 (contingent)	36.6	90.0
C2 (contingent)	36.6	106.0
NC (outside shock)	36.4	102.7

Note. All entries are in units of secs. and are averaged over all subjects for the particular group.

Discussion

The results of previous studies investigating the effects of aversive stimulation during the acquisition of imprinting are uncertain. In the case of response independent shock, contradictory results have been obtained, whereas in the case of response dependent aversive stimulation, no information exists. Moreover, at least one author (Hess, 1973) has maintained a distinction between imprinting and learning based, in part, on the differential effects of shock in the two experimental paradigms. The present research, then, attempted to analyze the effects of the delivery of response dependent aversive stimulation, as well as the effects of different levels of intensity of shock, during the acquisition of imprinting.

Based on the results of the present study it is reasonable to conclude that during the training trials shock increased the time that a subject required to approach the imprinting object (latency to approach the stimulus). Furthermore, within the levels used in this study, the stronger the intensity of the shock, the longer it took the subject to approach the stimulus object (based on the significant, positive linear trend). On the other hand, there appeared to be no difference in terms of where the shock was applied; no significant differences were found whether the aversive stimulation was applied on a response contingent basis close to, or distant from, the imprinting stimulus, or in another location where the imprinting stimulus was not present.

These results, however, apply only to the training situation. In the test situation, 24 hrs. later, two indices of the effects of the aversive stimulation were chosen to indicate if the effects (or absence of any effects) of the shock were restricted to the particular behavioural measure used in the training session or if they generalized to other measures of imprinting not specifically used in the training trials. No significant differences in the behaviour of the subjects were found, either in terms of the measure used in training or in terms of the time spent near the imprinting object. Therefore, although shock increased the approach latency of the subjects during the training session, shocked and unshocked subjects displayed no differences in either the latency to begin following or the amount of time spent near the stimulus in the later testing session.

Generally speaking, these results are in close agreement with many of the results of other studies investigating "instinctive" behaviours as well as studies of "conventional" learning situations. For example, in a study in which Peking ducklings had previously been imprinted to a stimulus, Barrett et al. (1971) reported that there was a significant reduction in the amount of time that imprinted subjects spent following the stimulus when that response was punished. Furthermore, Barrett et al. (1971) found that when the following response was no longer punished, recovery of the response was relatively rapid and resumed its pre-shock level. These results are very similar to the results of the present study in which there was a significant increase in the time taken by subjects to approach the stimulus object at the time of shock presentation but no differences in this same measure during the test situation given 24 hrs. later. Thus the results of studies in which shock was applied after subjects had been imprinted to a stimulus are similar to the results of the present study in which aversive stimulation was applied during the acquisition of imprinting.

Furthermore, there is similar agreement between the results of the current study and the results of studies involving other "instinctive" behaviours, as well as studies of learning. As previously mentioned, the application of response dependent aversive stimulation in learning situations, for example, results in the suppression of the punished response. Furthermore, "the degree of suppression is a monotonically increasing function of the level of intensity of the punishment" (Church, 1963, p.381). In one experiment, for example, Karsh (1962) trained rats to run to the goal area of an 8 ft. runway to receive food reinforcement. After this response had been established, the rats were given various levels of shock intensity at the goal area. Karsh (1962) found that the application of 75 volts had little effect on the running speed of the animals whereas 300 volts completely eliminated the response. Subjects who received 150 volts, however, ran slower to the goal area but did not cease to respond. Therefore, the effects of the intensity of the aversive stimulation obtained in the present study are consistent with results reported in other studies investigating learning processes.

In his review of the effects of punishment in learning situations, Church (1963) has postulated an explanation governing the intensity of the aversive stimulation that may also account for some of the obtained results in the present study. He has stated that as the level of shock is increased, four different phenomena may emerge. With mild levels of shock intensity, detection occurs, and as the intensity increases, temporary suppression, partial suppression, and total suppression of the response may be manifested (followed by complete recovery, incomplete recovery, or no recovery of the behaviour respectively). This possibility, then, may also account for the significant differences found between the 1 ma and the 3 ma shock conditions in the present study. Animals receiving the 1 ma shock were receiving the stimulation which had a slight, but noticeable effect on their behaviour; the 3 ma shock, on the other hand, produced a greater effect, temporarily suppressing the approach response of these subjects. The 2 ma shock group also exhibited suppression of the response but to a lesser degree than did the 3 ma group. If a stronger level of aversive stimulation had been used in the present study, moreover, it is possible that the approach responses of those subjects would have been eliminated entirely. Beyond this point of conjecture, however, the present results are in close agreement with the results of studies of learning.

There is further evidence that a relationship may exist between the results of this study and results found in learning situations. Some studies of learning have suggested that there is a gradient in approach responses directed towards a "goal" area and, as well, a gradient in the strength of avoidance responses directed away from an area in which shock has been applied (Brown, 1948; Bugelski & Miller, 1938). In the case of approach, for example, the closer the subject is to the "goal" area, the greater the "strength of the animal's approach responses" (Brown, 1948, p.463). In the case of avoidance response, however, a subject placed near the shock point tends to display a stronger tendency to avoid the area than one that is placed farther away (Bugelski & Miller, 1938). If this explanation is applied in the present study, then, it could be predicted that subjects in the NC group (in which shock was applied outside the alley) would take less time to approach the "goal" area (the area defined as an approach response) simply because there was no area to avoid in the imprinting apparatus. As seen in the columns of Table 4, there was more suppression of the approach response when shock was applied to the subjects in the contingent groups (C1 and C2); this possibility may account for the differences among the groups that were found in the present study. Although these differences are not statistically significant, they may be considered in general agreement with the above statements governing learning situations.[7]

Another explanation taken from studies of learning may also account for the differences among the groups found in the present study. Church (1969) has stated that in learning situations there may be greater suppression of a response in an immediate punishment group than in a delay-in-punishment group; once again the results of the present study are consistent with this general statement. Subjects in both groups C1 and C2 received immediate punishment for approaching the imprinting stimulus object. Subjects in group NC, however, may be considered a delay-in-punishment group for these subjects were first exposed to the imprinting stimulus and then removed and placed in another apparatus before receiving the shock. Although the time involved between the end of the trial and the delivery of the shock was very short (in the order of a few seconds), it has been shown that in learning situations, even a 5 sec. delay is sufficient time for punishment to become less effective (Church, 1969). Thus, once again, the present results are consistent with the results of studies investigating learning processes.

It is important to remember, however, that the above two comparisons deal with differences among the groups that did not reach significance level adopted for use in the present study. Indeed, the present data were analyzed using a very liberal test since this study was a first attempt at evaluating the effects of contingent aversive stimulation in the imprinting situation. The Geisser-Greenhouse Conservative F Test, for example, set the probability level for the groups data at $p < .10$[8] and if such a level was accepted throughout the study, the overall EW error rate would have risen to approximately .70. However, this situation does not negate the possibility that if such differences are due to the experimental treatment of the different groups, that such results are consistent with results of studies of learning.

To review the situation, then, Hess (1964, 1973) maintains that shock enhances responding during the acquisition of imprinting but these results were not obtained in the present study. In the response contingent situations studied here, shock increased the time required by the subjects to approach the stimulus object. Furthermore, the increase in response time was a linear function of the increase in shock intensity. In a later testing situation, however, no differences in any of the groups were found, either in terms of the time required to approach the stimulus object or the time spent following the imprinting stimulus. It would appear, therefore, that the application of shock may only have a temporary effect on the behaviour of the subject at the time of application, and produces no demonstrable difference in later imprinting responses. In short, enhancement of the imprinting response did not occur either during, or after, acquisition and this evidence as well as the results of other studies previously reported (Barrett, 1972) appears to refute those assertions made by Hess (1964, 1973).[9]

There are, however, several possible explanations to account for the differences of the effects of aversive stimulation in the present study and the study by Kovach and Hess (1963) upon which Hess (1964, 1973) bases his claims. One explanation may be that the subjects in the present study were not actually imprinted to the stimulus during the training procedure and thus no differences would be expected in the testing situation. That is, it is possible that the exposure time during the training trials was insufficient for attachment to occur. Hoffman and Ratner (1973), for example, have reported that a 2.5 min. exposure did not prevent ducklings from displaying fear responses when the stimulus was again presented to them five days later. On the other hand, Martin and Schutz (1975) have found no differences in the strength of attachment for subjects which followed an imprinting stimulus for either 5, 10, or 20 min. (test-retest interval was either 2, 5, or 8 days following the imprinting experience).[10] Furthermore, these same authors conclude that "even a minimal amount of exposure is capable of strongly affecting subsequent behavior if this exposure occurs to a model for which some innate attraction exists" (Martin & Schutz, 1975, p.76).[11] Similar statements concerning the rapid formation of an attachment have been provided by other authors including Hess himself (Hess, 1973; Hoffman & Solomon, 1974). Nevertheless, it would be difficult to assert that imprinting had definitely occurred in the present study; perhaps a suggestion made by Graves and Seigel (1974) best describes the present study. These authors have stated that "results of studies utilizing one or a few brief exposures of subjects to 'imprinting' models should not necessarily be interpreted in terms of preferences which are imprinted but rather in terms of tendencies toward imprinting" (Graves & Seigel, 1974, p.245). It is clear that a factorial study involving different lengths of exposure and different numbers of exposures is required to determine accurately the amount of time required for imprinting to occur.

A second explanation for the obtained differences between the two studies involves the measure of imprinting used in the present study. It is possible that the occurrence of approach behaviour does not necessarily indicate that an attachment is taking place; rather "some approach behavior might be an expression of curiousity" (Zajonc et al., 1974, p.581). On the other hand, other authors have also pointed out that following (the measure used in the study by Kovach & Hess, 1963) may not necessarily be equated with imprinting (cf., Barrett et al., 1971; Wood-Gush, 1963). Furthermore, it has been repeatedly demonstrated that exposure to an object leads to different behavior at a later date (despite the measure used) as compared with nonexposed animals (cf. Hess, 1973; Sluckin, 1965). In short, in the absence of any systematic attempts to assess the time course and intercorrelations of the different measures, the present study accepted approach behaviour as a measure of attachment.

A third explanation of the data obtained in the present study involves the time of the retest. Although it is unlikely that a delay of more than 24 hrs. would have produced results that were different from those obtained, it may be possible that at 36 hrs. of age the chicks were still being imprinted to the stimulus object. This possibility, however, appears counter to the statements of many investigators (Hess, 1964, 1973; Hoffman & Ratner, 1973). Hess (1964), for example, believes that there is a well-defined critical period in which imprinting occurs which lasts until approximately 30 hrs. of age; beyond this age fear responses are displayed. Hoffman and Ratner (1973) concur; they state that if a subject is not exposed to the imprinting stimulus "during the first 20 or so hours post-hatch, subsequent exposure to that stimulus elicits strong fear-like reactions" (Hoffman & Ratner, 1973, p.534). This statement was also confirmed by the present author. Previous pilot work indicated that subjects which were not exposed to the imprinting stimulus until 36 hrs. of age displayed characteristic fear-like responses including freezing, defecation, and a high rate of distress calling when first introduced to the test situation. In addition, subjects accumulated little if any time following the stimulus and often fled to the corner of the apparatus when the object approached. This behaviour was not characteristic of the subjects previously exposed to the imprinting stimulus, however; therefore, it appears that the prior imprinting experience did have an effect on the subject's behaviour which was later manifested in the test situation. Thus 36 hrs. post-hatch was chosen as an appropriate testing age.

Another possible explanation to account for the differences between the results of this study and those obtained by Kovach and Hess (1963) involves the method of shock delivery; Kovach and Hess (1963) used wing-shock while foot-shock was used in the present study. Because foot-shock was chosen, the subject's feet had to be dipped into water before the start of the first and third trials in order to ensure that the chick received the shock. Judging by behavioural indices (jumping, distress vocalizations, etc.) there is no doubt that the subjects received the shock. Furthermore, the various intensities of shock did not appear to impair the subject's motor responses or incapacitate the chicks in any other way. Nevertheless, because of individual differences in the conductance of electricity through a chick's feet, an exact control of the parameters of the punishing stimulus that a subject received was not possible (Church, 1963). Perhaps future studies should employ a different means of shock delivery such as the wing-shock procedure proposed by Hoffman and Ratner (1974).

Another possible reason for the obtained differences in the results of this study and those of Kovach and Hess (1963) involves the removal of the imprinting stimulus at the end of each trial during the training session. In the training situation all subjects received what can be described as response contingent withdrawal of the imprinting stimulus and it is possible that this situation may have influenced the subject's behaviour. A study by Hoffman, Stratton, & Newby (1969), for example, indicates that punishment can be delivered to an imprinted subject by means of response contingent withdrawal of the imprinting stimulus. That study, however, involved the removal of a previously imprinted stimulus; the present study involved the removal of the stimulus while the subject was undergoing the imprinting experience. In fact, the results of the present study indicate that the removal of the imprinting object did not diminish the approach response of the subjects in the control condition. Rather, as shown in Table 7, approach latency times for subjects in the no-shock condition continued to decrease throughout the five trials. It is possible, however, that an interaction involving one aversive event (the removal of a potential positive reinforcer) with another aversive event (shock) may have affected the behaviour of the subjects in the other experimental conditions. More information is required to assess this possibility, however.

In summary, the effects of aversive stimulation on the acquisition of imprinting as determined by this study are not in agreement with results obtained by Kovach and Hess (1963). There are a number of differences in the designs of the two studies, however, which make it difficult to compare the results directly. Furthermore, there are a number of uncertainties in the imprinting literature that require further investigation. Nevertheless, Hess (1964, 1973) has made some "universal" claims concerning the effects of aversive stimulation during the acquisition of imprinting that are not in agreement with the results of the present study nor with the results of other studies reported in the literature.

While the results of the present study are not in agreement with statements made by Hess concerning the facilitating effects of aversive stimulation, they also cast doubt upon a similar explanation proposed by Pitz and Ross (1961). These authors have suggested that exposing an animal to an arousing stimulus (arousal being defined as the total amount of stimulation impinging upon the organism) while the subject is in the presence of the imprinting stimulus should facilitate the

Table 7

Latency Times for Control Subjects Across Trials - Training Data

Trial				
1	2	3	4	5
124.75	55.17	51.42	34.33	26.83

Note. All entries are in units of secs. and are averaged over groups.

attachment response. Assuming that shock is an arousing stimulus (as defined by Pitz and Ross, 1961), then, the application of shock in both the C1 and the C2 conditions should lead to a decrease in the time required for approach (thus indicating an increase in attachment). This facilitation effect did not occur, however; in fact, as shown in Table 4, these groups of subjects had the longest latency times of all groups whenever shock was applied. These results, then, would not support the arousal hypothesis postulated by Pitz and Ross (1961).

More recently, a theory has been proposed to account for the phenomenon of imprinting. This theory, the opponent-process theory, was originally proposed by Solomon and Corbitt (1973) to account for motivational processes and was adapted to the imprinting situation by Hoffman and Solomon (1974). According to this theory, the onset and maintenance of an affect-arousing stimulus (either positive or negative in hedonic quality) creates a primary motivational state called the A-process. The occurrence of the A-process automatically arouses an affective process (B-process) which has an opposite hedonic effect to that of the A-process. Removal of the affect-arousing stimulus, then, results in the A-process quickly dissipating while the B-process disappears in a slower manner. Therefore, a motivational after-effect occurs which is opposite to the original state generated by the stimulus presentation.

It is difficult to accommodate the results of the present study to this theory. In terms of the theory, the presentation of the imprinting stimulus would appear to have a positive hedonic quality (A-process); indeed, Hoffman and Solomon (1974, p.153) state that during imprinting, subjects "are predisposed to react positively, with pleasure, to the special class of visual stimulation provided by moving objects". The removal of the visual stimulus, then, would result in the hedonically negative B-process, perhaps measured in terms of increased distress vocalizations or withdrawal from the area of the stimulus compartment. Unfortunately, neither one of these measures were recorded in the present study. Furthermore, shock, a negative hedonic quality, was also introduced in the present imprinting situation. The application of the shock should either increase the number of distress calls or decrease the approach tendencies of the subject (that is, produce a negative hedonic A-process).[12] Removal or cessation of the shock, then, would result in the more positive B-process, perhaps measured by a decrease in the number of distress vocalizations or an increase in the approach tendencies. As previously mentioned, however, shocked animals took longer to approach the stimulus, while the number of distress calls was not recorded. It would appear then, that according to one measure, the A-process did not dissipate as quickly as the theory suggests. It is possible, however, that the interaction of the positive and negative hedonic states brought on by the different stimuli may have produced different effects which resulted in the increase in time taken by the subjects to approach the stimulus. In short, it is difficult to account for the present results in terms of the opponent-process theory.

It is somewhat easier to accommodate the present data to the reinforcement model of imprinting proposed by Hoffman and Ratner (1973), however. In their model, imprinting is accounted for

in terms of familiar behavioural processes by postulating that

> certain aspects of imprinting stimuli are primary reinforcers that innately elicit filial behavior. In doing so, these aspects serve as unconditioned stimuli, enabling the development of familiarity with the other characteristics of a given imprinting stimulus through classical conditioning. Familiarity serves to present novelty-induced fear reactions which would otherwise compete with the filial response at later stages of ontogenetic development. (p.527)

Furthermore, the model also suggests that the two types of delivery of aversive stimulation will have different effects; the response contingent situation would reduce the subject's tendency to make the particular punished response while in the response independent situation response facilitation would occur by increasing the subject's attention and movement toward the appropriate arousal-reducing stimulus. In the present study, then, a response decrement did occur in the case of the response dependent shock while the delivery of response independent aversive stimulation was not investigated. A "carryover" effect into the test phase may have been expected if conditioning had indeed occurred, however, and this result was not obtained in the present study. Subjects in all groups took almost the same amount of time to approach the imprinting object during the test phase. Thus, although the reinforcement model does account for some of the results of the present study, a more definitive test of the model awaits to be done.

In conclusion, according to the results of the present study, it would appear that in imprinting situations the application of response contingent shock reduces the tendency of the subjects to approach the imprinting stimulus. In addition, the stronger the intensity of the shock, the greater the time required to approach the stimulus. No enhancement of the imprinting response ever occurred. Furthermore, the application of the shock had only a temporary suppressive effect at the time of application; in a retest given 24 hrs. later, no significant differences among the various groups were obtained either in terms of the original measure of attachment used in the training situation or in terms of the time spent near the stimulus. Therefore, it is reasonable to conclude that the application of aversive stimulation during the acquisition of imprinting has no permanent effect on the expression of the attachment response. It is also reasonable to conclude that the assertions made by Hess (1964, 1973) regarding the enhancing effect of aversive stimulation in the imprinting situation, require considerable modification.

Furthermore, the results of the present study are generally consistent with the results of studies investigating other "instinctive" behaviours as well as studies of learning. Therefore, there is also very little basis upon which Hess (1973) can continue to maintain his imprinting/learning distinction based on the differential effects of aversive stimulation in the two situations.

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Footnotes

1. In this paper the terms "aversive stimulus", "noxious stimulus" and "shock" will be used interchangeably.

2. In the present review the term "punishment" will refer to the response contingent delivery of aversive stimulation that reduces the probability of the particular response.

3. It should be pointed out that the difficulty in distinguishing between response contingent and non-contingent aversive stimulation is not unique to the study by Kovach and Hess (cf., Brush, 1971).

4. It should be noted that Pitz and Ross, 1961, do not state that the tone was an aversive stimulus; rather they describe the sound as an "arousing stimulus".

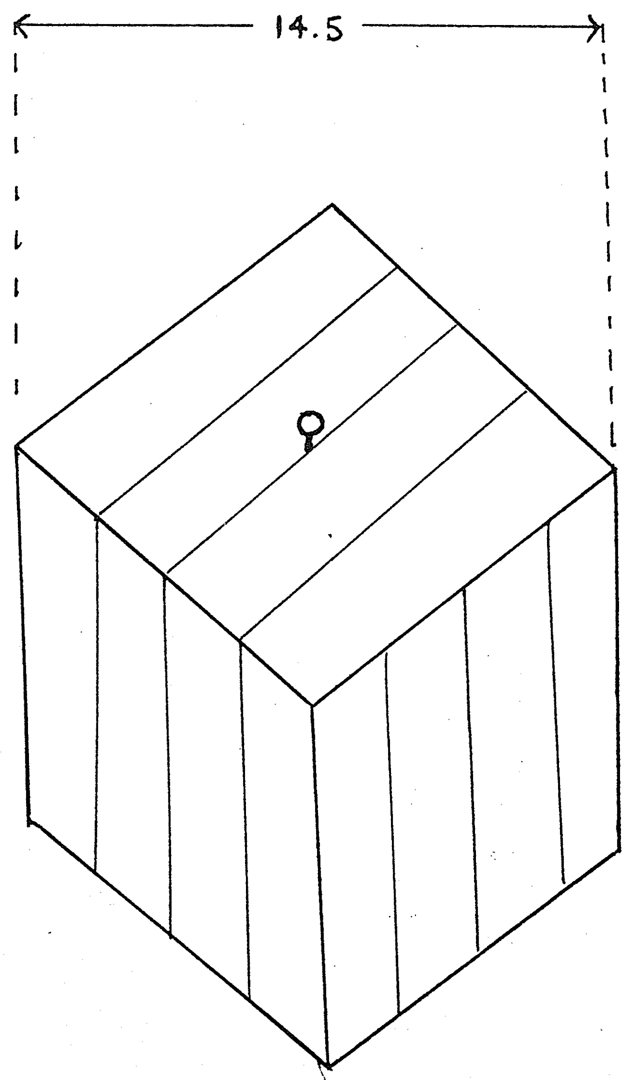
5. As shown in Figure 5, the distance from one corner of the cube to the opposite corner (diagonally across) was 14.5 cm; this distance, then, added to the two 7.5 cm distances marked by the pipe cleaners gave a total length of 29.5 cm.

6. Each source of variation has an F value and probability level determined by the Multivariate Analysis of Variance (Finn Program). No values for the SS or MS were obtained. However, each source of variation has been subdivided into the latency and following components and the SS, df, MS, and F for each of these components has been provided. These values, however, represent a UNIVARIATE test for each component and are only provided so that the reader may obtain a clearer idea of the test results.

7. It is also possible that differences may have existed between groups C1 and C2 in terms of the time required for approach. Whereas in group

Figure 5

Figure 5. A top view of the stimulus object indicating that the distance from one corner to the opposite corner (diagonally across) was 14.5 cm.


14.5

C1 the "goal" area and the "shock" area were the same, this situation was not the case for group C2. In this latter group, then, subjects may have taken considerable time to move to, and through the shock area, but once that had occurred, moved with increasing speed to the "goal" area. Such an explanation would be possible if "gradients" did exist. Unfortunately, the time taken by subjects in group C2 to traverse the portion of the alley between the "shock" area and "goal" area was not recorded; perhaps future experiments may wish to record such a time.

8. Similarly, the shock x trial interaction which also attained a $p < .06$ in the present study, would have an overall $p < .19$ if the Geisser-Greenhouse Conservative F Test had been used.

9. Strictly speaking, however, the present results do not agree with those obtained by Barrett (1972), either. He found that the suppressive effect of the aversive stimulation continued 24 hrs. after the stimulus had been paired with shock whereas the present results indicated that the shock had only a temporary effect at the time of application. Unfortunately, Barrett (1972) does not provide data for each of his three test sessions; instead all data for each duckling is collapsed across the test sessions into one data point. Thus it is impossible to tell if the suppressive effect of the aversive stimulation continued at its same level at 24 hrs. as it did at 2 hrs. post-training, or if in fact, a gradual increase in time was spent with the stimulus paired with shock. Furthermore, it is difficult to compare the results of the two studies directly as different species and different measures of imprinting were used.

10. If the average latency times shown in Table 7 were added together, subjects in the control condition had an approximate exposure time of 5 min. Furthermore, as will be mentioned later in the discussion, this accumulated score represents the lowest average exposure time of any group of subjects.

11. As previously mentioned, the size and colour of the stimulus object used in the present study were chosen as they have been shown to be effective in eliciting approach responses.

12. Once again, this assumption would have to be verified.