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EFFECTS OF VISUAL COMPLEXITY DURING REARING ON CHICKS' REACTIONS TO ENVIRONMENTAL CHANGE

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Experimental sensory deprivation and variation of environmental complexity soon after a bird hatches or during the latter part of weaning in mammals may have prolonged effects on anatomy, physiology and behaviour. It is to be expected that attempts to control experience will have the greatest effects on animals at these stages of development for the sensory input increases most rapidly then.

The experiments of Hinde, Thorpe & Vince (1956) on moorhens and Schaller & Emlen (1962) on various species of precocial birds, all a week or more old, suggested that the reactions shown by birds to an environmental change were reduced if the complexity of the rearing conditions was greater. Since humans were visible to the birds during rearing in the more complex condition and during the test it is possible that the effects of the rearing conditions were specific rather than general. Similar suggestions as to a general effect of rearing complexity have, however, been advanced as a result of work with rodents (e.g. Hunt & Otis 1963). In the experiment described here several rearing conditions which differed in visual complexity were used, but neither the observer nor any other human was visible to the birds during rearing or testing.

The chicks used in the experiment were tested at 6 days and their behaviour before and after an environmental change compared. This age was chosen because in a previous experiment in which undisturbed chicks were watched at different ages up to 10 days old (Broom 1969a), several measures of behaviour were most frequently recorded on day 6. The rearing conditions used are selected with reference to the extensive literature on the preferences of young chicks (Sluckin 1965). The silent illumination of a torch bulb continuously present in the pen was the test used.

Methods

The pen size and shape and methods of incubating, heating, lighting, feeding and behaviour recording are merely summarized here for they have previously been described (Broom 1969b). The chicks were kept in isolation in one of six rearing conditions, see below, from shortly after hatching until after the test at 6 days. During this time they received ample food and water and could not see any humans except for 5 to 10 sec each day when the water containers were filled. On day 6 the birds were observed for 15 min while undisturbed and then for a further 15 min after the illumination of a 6 V, 0·3 A torch bulb in the pen. No illumination change, except those caused by their own movement, could have been seen by the chicks since removal from the incubator, for the room was continuously illuminated by striplights. The birds were watched through a vertical, one-way, plastic-film window 1·5 m diagonally above the pen. Since the chicks were illuminated but the observer behind the window was in darkness, the chicks could not see the observer and never stared fixedly at the observation point. Using fifteen measures the behaviour was coded by one or two pen deflections on to the twelve channels of a moving paper event recorder.

Recording was carried out using the 'period occurrence' technique in which the animal is watched continuously and, at the end of successive periods (in the experiment 10 sec), pens are deflected to signify which activities occurred during that period. See previous papers (Broom 1969a, b) for further discussion of this recording method. No noise was made during recording.

The chicks were reared in six different conditions. All pens were the same shape and size (floor area 700 cm^2, walls 23 cm high) and contained only a water dish, a torch bulb in a holder on the wall, and food on the floor.

(i) GREY (G). All walls painted matt grey ($N = 32$).

(ii) STATIONARY OBJECTS (S). The right-hand wall of each pen was made of transparent Perspex which allowed the chick to see into the adjacent pen. This was the same size as its own but filled with objects which were of varied colours and shapes. The illumination was such that it was not possible for the chick to see its own reflection in the Perspex. The objects were:

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(a) an approximately spherical ball of white cotton-wool, about 5 cm in diameter, mounted on the spindle of a motor, in front of a grey board 15 cm × 10 cm; (b) a piece of white card 15 cm^2; (c) four small pieces of coke whose mean diameter was 3 cm; (d) a red rubber tube 15 cm long; (e) a wooden cube of side 4·5 cm, painted red (N = 30).

(iii) MOVING OBJECT (O). Exactly the same as (ii) above, except that the motor was continuously working so that the cotton-wool ball traced a circle once every 2 sec. The motors were selected for their quietness but they did make some noise (N = 24).

(iv) MIRROR (M). The same as (i), except that a mirror (18 × 15 cm) was glued centrally, but touching the ground, to the right-hand wall of the pen (30 × 23 cm) (N = 14).

(v) STATIONARY OBJECTS AFTER ALTERNATION (s). A time clock with six switches was connected via a relay to the motor so that the motor was moving for 4 hr and stationary for 4 hr. The birds were tested between 09.30 and 12.30 hours during a period when the motor was stationary. No observations were made during the 30 min after the motor stopped or the 30 min before it started again (N = 12).

(vi) MOVING OBJECT AFTER ALTERNATION (o). The same as (v) but watched while the motor was moving (N = 12).

For each batch of birds, pens with birds reared in different ways were alternated around the room. The sound levels in the pens were measured and some overlap was found between the quietest pens from which a moving object could be seen and the other rearing conditions. The noise of the striplights and thermostatically controlled blower heater was greater than that of the motors. Apart from this small sound difference, the only differences between rearing conditions were visual.

All statistical comparisons are restricted to birds from the same batches of eggs.

Results

1. Reactions Common to All Conditions

As in the experiment in which chicks of different ages were studied (Broom 1969b), all birds showed an initial orientation reaction when a torch bulb was illuminated in their homepen. This was followed in 92 per cent of chicks by one or more loud calls. The subsequent behaviour was considerably influenced by the rearing conditions. Comparisons between behaviour before and after the illumination showed changes in all measures of behaviour but the magnitude and duration of the change varied from measure to measure.

The incidence of twittering, preening, pecking the ground, or drinking by birds in all rearing conditions was reduced immediately after bulb-on. This behaviour change can be quantified by comparing the latency of occurrence of each activity after bulb-on with the median interval between bouts of that activity before bulb-on. For each rearing condition, the latency of twittering, preening, and pecking the ground or drinking was greater than the median interval between bouts while undisturbed ($P<0·01$, 2-tailed Wilcoxon matched pairs test). The frequency of loud calls increases after bulb-on so that for each condition the latency of calling loudly after bulb-on was shorter than the median interval when undisturbed.

2. Descriptions of Reactions and General Differences Between Conditions

The changes in behaviour which occurred when the bulb was illuminated were similar in the Grey pen and Stationary objects conditions. Where any difference between rearing conditions was apparent in the change shown by a measure of behaviour after bulb-on, as compared with the undisturbed behaviour, much the largest difference was always that between Grey pen and Moving object or between Stationary objects and Moving object. Birds reared in the other three conditions were usually intermediate but closer to the Moving object condition. In summary, the behaviour of the birds in the different conditions was as follows.

(i) A brief period of complete immobility is followed by a period lasting several minutes during which loud calls and jumping may occur but walking, preening, pecking the ground, drinking and twittering are all reduced. The measures preening, pecking the ground and twittering then increase to a higher level by the end of 15 min, by which time loud calling and jumping have ceased and the bird is moving for most of the time.

(ii) Almost the same as Grey pen in every respect. No comparison of changes showed a difference for which $P<0·1$. These birds did not go to the partition at bulb-on and there was no increase in time near the partition.

(iii) The bird rushes to the partition near the moving object within 10 sec of bulb-on and, for a few minutes after, walks up and down in front of it, calling and pushing against it.

(iv) The reaction is intermediate in most respects between Grey pen and Moving object. It is shorter or less obvious than Grey pen and includes much time spent near the mirror.

(v) The reactions of these birds are much more like Moving object than like Stationary objects birds. They call less than Stationary objects birds and spend much time near the partition even though the object is not moving. Their period of reduced activity is somewhat longer than that in Moving object birds although not as long as that in Grey pen or Stationary objects.

(vi) Again, the reaction is more like that of Moving object birds but they call more and jump slightly more often. There was little difference between the two groups tested after alternation.

3. Analysis of Data

The gradual modification of behaviour which occurs after bulb-on renders insufficient any measurement of the reaction by comparing behaviour during a fixed period after bulb-on with undisturbed behaviour. For example, a measure of behaviour which shows an initial decrease in frequency of occurrence after bulb-on usually shows a subsequent increase above the undisturbed level, so that consideration of both these reaction phases together does not optimally reveal the extent of the reaction. With the exception of Table I, most of the data are thus presented as rates of return to the undisturbed level for each measure. By this means a comparison of rearing conditions is possible.

The median frequencies of occurrence of activities in the 15 min before and after bulb-on are compared in Table I for each rearing condition. Each measure for which large changes ($P<0{\cdot}05$, Wilcoxon 2-tailed) occurred is included. The figures in the Table are the result of subtracting the median value before bulb-on from the median value after bulb-on. Thus in all conditions an increase in loud-calling and a decrease in preening is seen. Birds in the Grey pen and Stationary objects conditions show very similar changes but birds in the Moving object condition are different and those in the other three conditions are intermediate.

4. Attention to Partition

The rate of return to undisturbed behaviour is shown for three measures in Figs. 1, 2 and 3. The median percentage of 10-sec periods during which the measure was recorded in the 15 min while undisturbed and in the first, second, third, fourth, and fifth 3-min intervals after bulb-on is shown.

Those birds which could see a moving object during rearing spent 40 to 50 per cent of their time moving near that object while undisturbed but often spent almost all their time doing so after bulb-on (Fig. 1). There was a similar but smaller increase amongst birds reared with a mirror in the pen and for all four conditions; Wilcoxon matched pairs tests comparing the undisturbed level with the 15 min after bulb-on gave a value $P<0{\cdot}01$ (2-tailed). There was a drop towards the undisturbed level in the frequency with which the measure was recorded in the latter part of the 15 min after bulb-on. For Moving object birds, the figure for 3 to 6 min after bulb-on is considerably greater than that for 12 to 15 min ($P<0{\cdot}01$, 2-tailed Wilcoxon test). In contrast, birds reared in Grey pen and Stationary objects conditions showed a slight decrease in the frequency of attention to the partition (looking at it or moving near it)

Table I. Comparison of Median Percentage of Periods that a Measure was Recorded: 15 min After Bulb-on v. 15 min Before Bulb-on*

Rearing condition	Touching partition	Fixating bulb	Loud calls	Jumping	Twittering	Drinking	Preening
Grey pen (G)	0	NR	+10*	+1*	−3*	−2*	−1*
Stationary objects (S)	+1·5	+24*	+13*	+1*	−2	−2*	−2*
S after alternation (s)	+15*	+21*	+5*	0	+1·5	+0·5	−4*
O after alternation (o)	+38*	+17*	+11*	+0·5	−4	0	−3
Mirror (M)	+17*	NR	+2*	0	−1	−4*	−3*
Moving object (O)	+28*	+12*	+3*	0	−1*	−1*	−3

*$P<0{\cdot}05$ (Wilcoxon matched pairs test, 2-tailed). NR — not recorded.

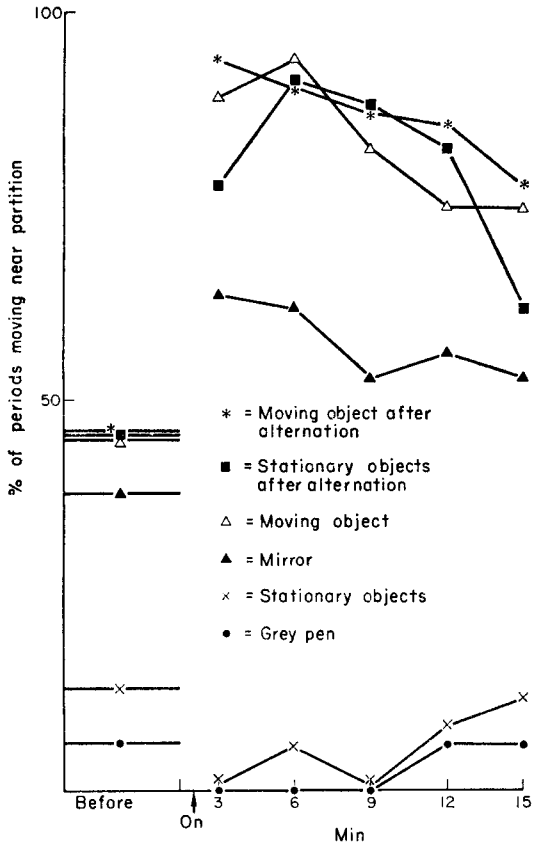

Fig. 1. Behaviour of chicks while undisturbed and in successive 3-min intervals after bulb-on. Each point is the median of 12 to 32 birds.

just after bulb-on and then an increase to the undisturbed level. Table II shows: (i) for the four conditions in which it was measured, the median interval between bouts of attention to the partition while undisturbed, (ii) the delay in seconds after bulb-on before the same birds looked at or moved near the partition, and (iii) comparisons using a Wilcoxon test. Values for P are quoted only if $<0{\cdot}1$, 2-tailed.

5. Extreme Reactions—Immobility

By other measures of behaviour, the reactions to torch-bulb illumination shown by those chicks which could see no moving object during rearing were more obvious to an observer and more prolonged than those of chicks which could see a moving object during rearing. The three measures of behaviour whose occurrence might be grouped as extreme reactions to environmental change are immobility (excluding sleep), loud calling and jumping. All three of these were very rare among undisturbed birds although it was scarcely possible to distinguish absolutely between freezing and sleep. All occurred independently of the localization of the bird in the pen.

An initial increase over the undisturbed level followed by a decrease during the 15 min after bulb-on was shown by the measures immobile (Fig. 2), fixating the bulb, calling loudly (Fig. 3), and jumping. For each measure, the initial increase was smaller and the return to the undisturbed level took less time if the chicks had been reared in the presence of a moving object or mirror. As an assessment of the duration of the reaction, Table III shows a measurement of the delay after bulb-on before birds were recorded moving in each 10 sec during a 3-min interval after bulb-on, if this criterion was reached, and the results of Mann–Whitney U tests on these data if $P<0{\cdot}1$ (2-tailed).

6. Fixating Bulb

Almost all birds fixated the illuminated bulb but the measure was recorded for conditions Stationary objects, Stationary objects after alternation, Moving object after alternation, and Moving object only. The median value for undisturbed birds was nil for each condition

Table II. Latency of Attention to Partition After Disturbance Compared with Previous Level (see text)

Rearing condition	Mdn interval in sec between bouts while undisturbed	Mdn latency in sec after bulb-on	Wilcoxon test
Grey pen (G)	70	255	$P<0{\cdot}01$
Stationary objects (S)	65	155	$P<0{\cdot}01$
Mirror (M)	30	55	
Moving object (O)	20	5	$P<0{\cdot}04$

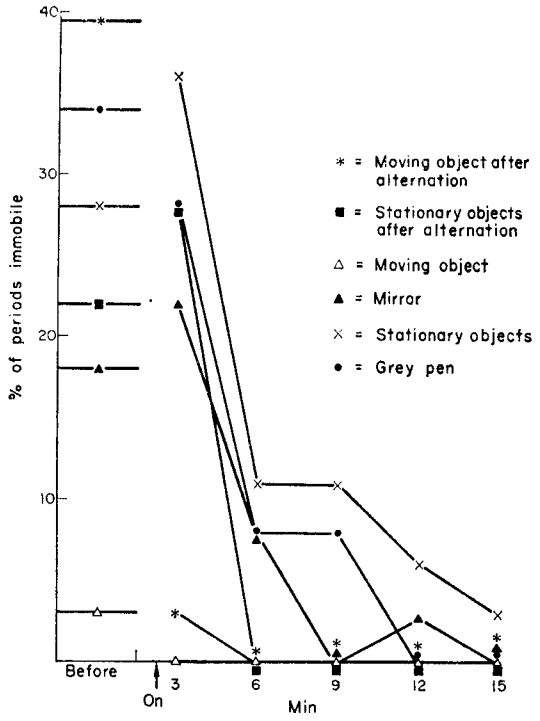

Fig. 2. Behaviour of chicks while undisturbed and in successive 3-min intervals after bulb-on. Each point is the median of 12 to 32 birds.

Table III. Mean Time Before Number of Periods Moving Reaches 100 per cent

Rearing condition	Delay (min)	Mann–Whitney U test	
Grey pen (G)	8·1	G v. O	$P = 0{\cdot}001$
Stationary objects (S)	8·4	S v. O	$P = 0{\cdot}0003$
S after alternation (s)	5·7	S v. M	$P = 0{\cdot}096$
O after alternation (o)	4·8	(s) v. O	$P = 0{\cdot}009$
Mirror (M)	6·9		
Moving object (O)	5·2		

but 97 per cent fixated the bulb after the illumination, usually within 20 sec. By 15 min after bulb-on the measure had declined to nil in condition Moving object but a slower decline from a higher initial level was shown by Stationary objects birds. Birds reared in the two Alternation conditions were intermediate. Since the undisturbed levels were so low, they can be directly compared with levels in the 15 min after bulb-on. Using a 2-tailed Mann–Whitney U test, the only comparison between conditions for which $P<0{\cdot}1$ was that between the Stationary objects and Moving object conditions. The median value for undisturbed birds was the same for these two conditions, but after bulb-on Stationary objects birds fixated the bulb more often ($P<0{\cdot}04$).

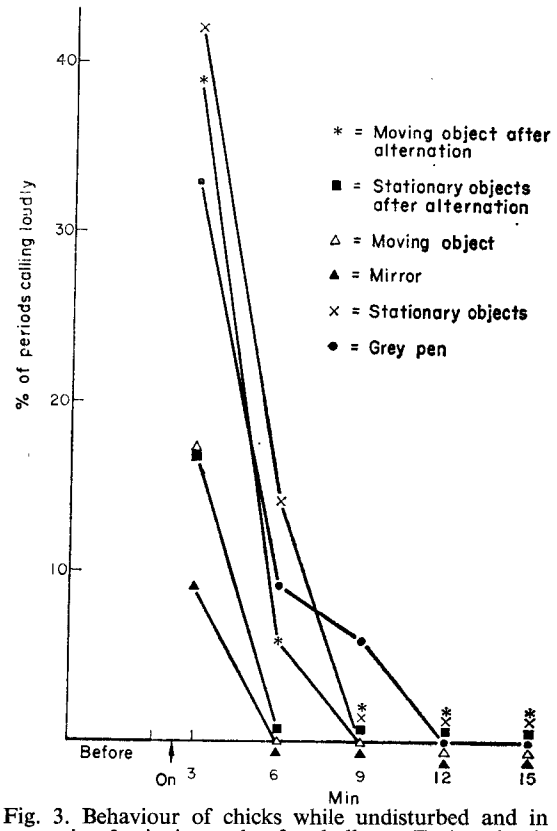

Fig. 3. Behaviour of chicks while undisturbed and in successive 3-min intervals after bulb-on. Each point is the median of 12 to 32 birds.

7. Loud Calls and Jumps

Figure 3 shows that Grey pen and Stationary objects chicks called more and called for longer than did Moving object chicks. Birds reared in these conditions also jumped more than others. Since the undisturbed level of calling loudly and jumping was very low for all rearing conditions, and any differences were never reversed after bulb-on, it is possible to compare birds in different conditions directly. Table IV shows the results of 2-tailed Mann–Whitney U tests (if $P<0{\cdot}05$), on comparisons between conditions: (a) number of periods in 15 min after bulb-on

Table IV. Rearing Condition Comparisons (After Bulb-on)

Comparison	loud calling 0 to 15 min	loud calling 3 to 15 min	jumping 0 to 15 min
G. v. O	/	<0·05	0·001
G v. M	0·02	/	0·009
S v. O	/	<0·02	/
(s) v. S	<0·05	/	0·02

during which loud calls were recorded, (b) number of periods between 3 and 15 min after bulb-on during which loud calls were recorded, (c) number of periods in 15 min after bulb-on during which jumping recorded.

8. Other Measures

Several other measures of behaviour were recorded and some of these changed considerably after bulb-on, as in a previous experiment (Broom 1969b). In each case the Moving object birds could be seen to have returned to the undisturbed level faster than Grey pen or Stationary object birds. The median undisturbed level for the measure 'pecking the ground' was the same for Grey pen, Stationary objects, and Moving object birds so a direct comparison between levels after bulb-on could be made. The greater frequency of pecking the ground by Moving object birds was apparent in the first 3 min (Stationary objects v. Moving object $P = 0{\cdot}0003$) and in the first 6 min (Grey pen v. Moving object $P = 0{\cdot}03$). Any large differences in other measures were between the Grey pen or Stationary objects and and the Moving object conditions.

There was some variation among birds as to which of the measures of extreme reaction to an environmental change, i.e. immobility, loud calling, and jumping, was shown most at bulb-on. Birds with a mirror in the pen and those tested after alternation but while the object was stationary showed a period of immobility but few loud calls or jumps. Those tested after alternation but while the object was moving showed little immobility but many calls and jumps in the first 3 min. It is therefore instructive to compare the combined levels of these measures of behaviour. Figure 4 shows the median percentage of periods during which any one or more of these measures was recorded. The differences between conditions in the extent and duration of the reaction to bulb-on are apparent.

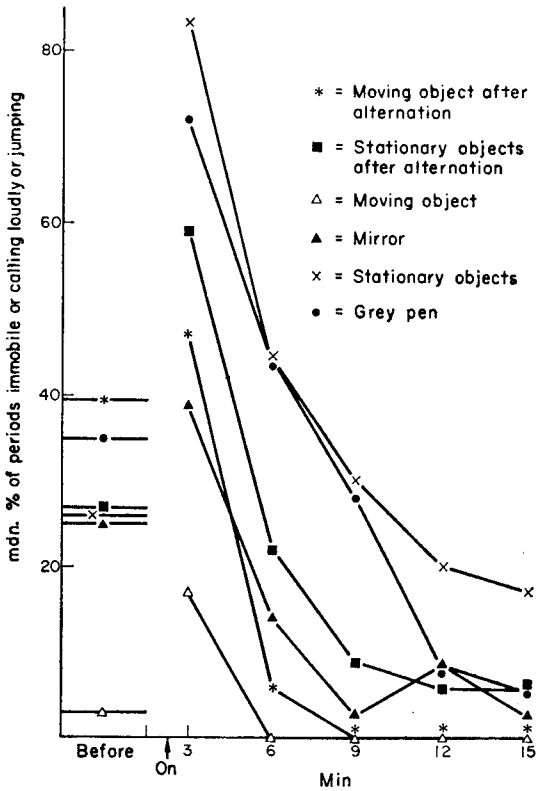

Fig. 4. Behaviour of chicks while undisturbed and in successive 3-min intervals after bulb-on. Each point is the median of 12 to 32 birds.

Discussion

The considerable effect of the presence of a moving object on the reactions of chicks to a novel change and the lack of any large difference between birds in grey pens and birds which could see stationary objects is in harmony with the differences and similarities between the behaviour of chicks in these conditions while undisturbed (Broom 1969a). A moving object elicited much attention from undisturbed chicks but little attention was paid to Stationary objects (loc. cit.). Since the differences in noise level were small and the objects behind the partition were the same for birds in Stationary objects and Moving object conditions, the differences in behaviour between the birds must be attributed to the movement.

The presence of a mirror leads to a very complicated visual input which is comparable in some ways with that received when looking at another bird (Kaufman & Hinde 1961) but no movement is seen unless the subject itself

moves. The mirror was not quite as effective as a moving object in reducing the reaction of a chick to a change.

Two factors must be considered in interpreting the results of this experiment. The differences between two conditions, in the behaviour observed, may be due to the complexity and specific characteristics either of the environment during rearing or of the test situation. It seems most likely that the rearing conditions are of paramount importance. The conditions in which the object was alternately moved and not moved were designed so that this problem might be circumvented. Both included a total of 3 days' experience of the object while moving and 3 days while it was stationary but one group was tested while it was moving and the other while it was stationary. There was very little difference between the reactions of birds reared in these two conditions. By almost every measure, the durations of their reactions were closer to those of Moving object birds than to Grey pen or Stationary objects birds and the median time spent near the partition after bulb-on was the same for the three rearing conditions in which a moving object was visible.

Many studies have shown that even brief exposure to a conspicuous moving or flashing object can affect the later preferences of young precocial birds (Sluckin 1965; Bateson 1966). In an experiment by Bateson (1964), prolonged exposure to stationary patterns affected the extent to which chicks followed or avoided a moving object, patterned in a familiar or unfamiliar way, after transference to a strange runway. No test in which such specific effects might be apparent was carried out in the experiment reported here but the general effect of reducing a chick's reaction to a novel change was detected only when a moving object was present during rearing.

These results can be explained in the same way as those of a previous experiment (Broom 1969b). Animals gradually learn the characteristics of their environment. The results of this learning, which might collectively be called an environmental model, form the basis for comparisons when the environment changes. As has been mentioned, different aspects of the environment elicit attention from chicks for different proportions of time. The presence of a rotating cotton-wool ball, because the chick pays attention to it, makes the rearing condition more complex and presumably modifies the model within the chick with which future environmental changes are compared. The test situation in this experiment is a visual change but is not otherwise similar to the moving object seen during rearing. Thus it seems that there is a general effect of rearing condition complexity on subsequent reactions to an environmental change. The particular aspects of the environment which elicit much attention from rapidly developing animals and hence affect their later behaviour must, however, vary from species to species.

The specific effects on behaviour due to the presence of an object as a moving green rectangle for a duckling (Stettner & Tilds 1966) or a cloth covered model for a monkey (Harlow & Zimmermann 1959) are to some extent comparable with the results of this experiment. The ducklings had previously been exposed to the moving green rectangle, which had elicited much attention from them, and the monkeys had spent much time on the cloth model monkey during rearing. When exposed to strange objects, both animals showed a less marked reaction if reared and tested with the familiar conspicuous object present.

Since it appears that an increase in environmental complexity can reduce the reaction of a chick to an unrelated, novel change it seems likely that the results of Hinde, Thorpe & Vince (1956) and of Schaller & Emlen (1962) also demonstrated a general effect. Such an unspecific effect is also likely to be a component of the results obtained using rather complicated tests in studies of young precocial birds' preference changes after previous exposure to moving objects and differences in the behaviour of newly weaned mammals after various treatments during infancy. The complexity of early experience must also affect the subsequent behaviour, including reactions to environmental changes, of young children and domestic animals.

Summary

The reactions of 6-day-old chicks to the illumination of a torch bulb in the home pen differed according to the conditions of rearing. Birds which were able to see stationary objects in an adjacent pen during rearing reacted in the same way as birds in a grey-walled pen but birds reared with a moving object visible reacted differently. The initial, very brief, orienting reaction was shown by all birds but after this those birds which had been reared with a moving object present for 3 or 6 days in total, and those which had a mirror on the wall, spent more time near the object or mirror than they had while undisturbed. The reaction to the novel change,

as measured by the extent and duration of the period of reduced activity and loud calling, was greater among birds reared in a grey pen or with stationary objects present than among those whose rearing conditions had been made more complex by the presence of a moving object or mirror.

It is suggested that the 'environmental model' formed within the animal as a result of experience during development is different, if that experience has been more complex, in such a way that an environmental change is followed by a less marked reaction.

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