Stimulus Preferences and Imprinting

Abstract. *Pekin ducklings were tested with respect to their preference for approaching one of two simultaneously presented, rotating, silent duck decoys, painted in a variety of colors or patterns. Some of the ducklings had not been given any previous visual experience other than that gained in a 20-minute introduction to the empty apparatus; others had previously been given the opportunity to follow one particular decoy for 20 minutes. The decoys could be grouped into three categories: those in the first category were treated as equivalent, that is, so long as the duckling had followed one of these models it would approach either. The decoys of the second category were ones to which "imprinting" occurred, that is, the ducklings showed a decided preference for the model they had originally followed, whichever it was. The third category included models, one of which was always preferred, though the controls showed no such preference. The effects of the imprinting procedure vary with the stimuli presented.*

The classical notion of imprinting compares that process to the impressing of a pattern upon a *tabula rasa*. However, we found that two differently colored papier-mâché duck decoys, while initially equally effective in eliciting the following response from young fowl, did not continue to have equal effects (*1*). Subsequent tests with both models simultaneously present and moving showed that most subjects preferred the varicolored to the white model, regardless which they had previously been exposed to. Controls that had no prior experience with one or the other models evinced no such preference. We concluded that either the cues by which the models were recognized were more salient in the moving varicolored model or that the initial exposure "activated" an independently determined preference for the varicolored model. Given these alternatives, one of the more important questions is whether the same characteristics of the models are relevant in all contexts. What, in fact, are the relevant characteristics of visually perceived models? The experiments related below are particularly directed towards this last question, the role of simple patterning and color.

The subjects were Pekin ducklings, incubated and hatched at 37° to 38°C and 70 to 80 percent relative humidity. Hatching occurred between day 26 and day 28 after the start of incubation. The ducklings were communally hatched in darkness and were then individually removed to separate cardboard boxes, about 12 by 6 by 6 cm. At least 6 hours after hatching and between 27 days and 28 days 6 hours after the start of incubation the ducklings were individually exposed to the training model for 20 minutes. This exposure constituted the training session. They were returned to their boxes and a brooder, kept at 35°C, and 22 to 25 hours later they were tested with two models simultaneously present, the training model and one other. This constituted the testing session.

The training apparatus was a circular table 180 cm in diameter and vertical sides 30 cm high. The floor was covered with brown sand, about 1 cm deep; the remainder of the interior was a flat grey color. In the center of the table was a white ring, 40 cm in diameter, which meant the ducklings had to confine their movements to a circular track 70 cm wide. For the initial exposure or training session, the training model was suspended overhead 3 cm above the arena floor. The model moved intermittently (moving 15 seconds, pausing for 5 seconds) along the periphery of the arena, at a rate of about 580 cm/min. The model emitted a recorded "kom, kom, kom" sound. Observations were made from an adjacent room through one-way glass.

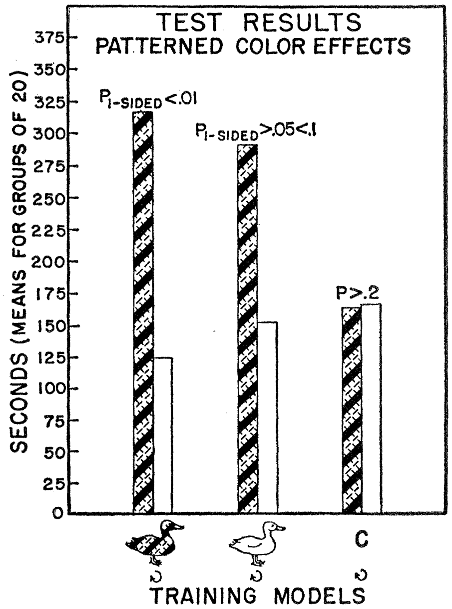

Fig. 1. A replication of the experiment with plain white and strikingly painted models (*1*), with the models on a rotating turntable (33⅓ rev/min).

The testing apparatus consisted of the same table from which the center ring was removed. In some experiments two models were suspended from opposite ends of an overhead bar and made to move as during the initial exposure except that they emitted no sounds. In other experiments, the models were placed upon turntables which rotated at 33⅓ rev/min. The two turntables and the duckling, when introduced, were at the apices of an equilateral triangle with sides of 100 cm.

Scoring of "approach" and "following" was by means of electric timers activated by an observer whenever the duckling (i) was within about 20 cm of the tail or about 8 cm of the side of the moving model and moving with it, or (ii) had been following until the pause and was still within the required distance, as estimated by the observer, or (iii), in the turntable experiments, had crossed a line drawn with a 20-cm radius from the model. The duckling's behavior was always unambiguous: either the ducklings followed closely or not at all.

All groups consisted of 20 subjects (and two or three groups per experiment). The figures show group means; the significance levels are based on the Wilcoxen matched-pairs sign test, two-tailed, except where otherwise noted.

No distinction was made between data derived from tests with moving and rotating models, although a curved arrow on the figure indicates that the rotating model was used. The rotating models were introduced on the basis of criticism by Bateson (*2*), who claimed that our former criterion for responding was too demanding of young ducklings. However, this criticism does not affect the validity of the conclusions drawn from earlier work, since equal-age controls were always used.

All models were adult-sized Mallard duck decoys made of papier-mâché; a loudspeaker was in the ventral surface.

In the first experiment (Fig. 1) we replicated the design in Klopfer, and Hailman and Klopfer (*1*), with the same plain white and strikingly painted models. Twenty birds were trained with each model; 20 controls were exposed to the same sound in the otherwise

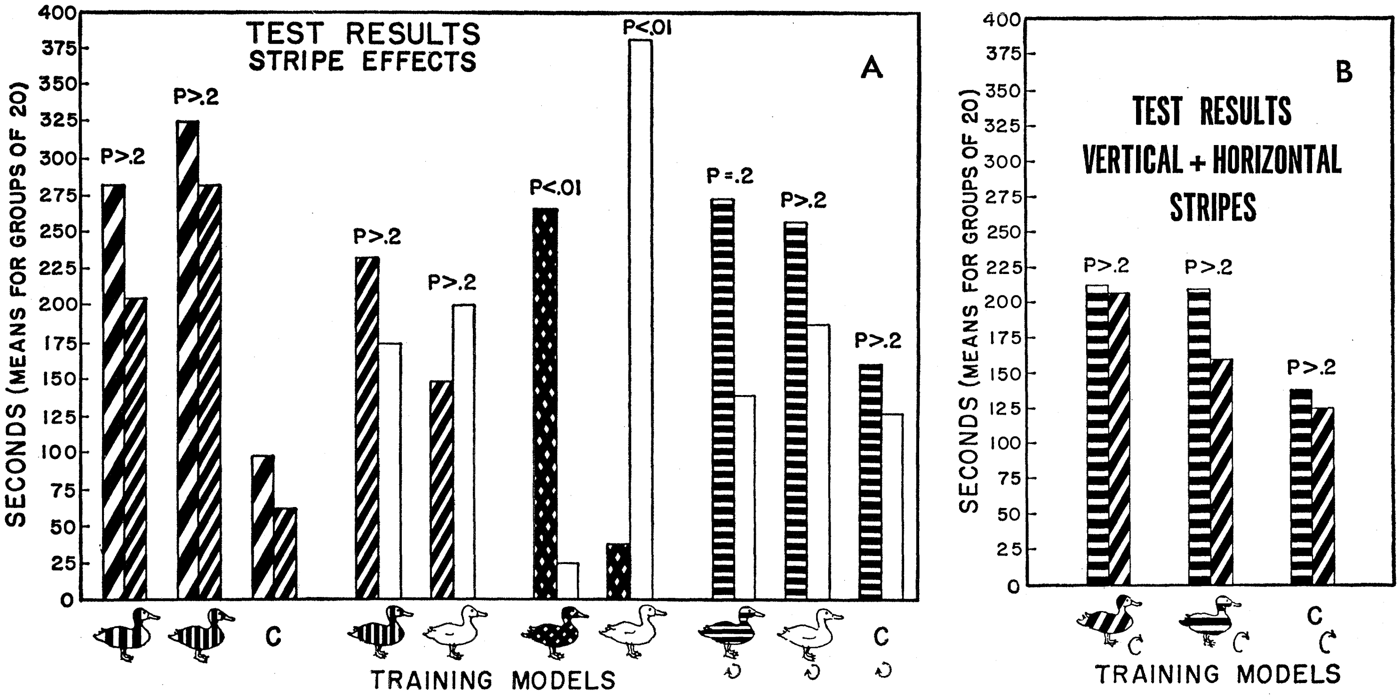

Fig. 2. The role of stripedness in imprinted preferences.

empty apparatus. Sixty ducklings were used, 20 in each group. Testing was with the models mounted on the rotating turntable. Untrained controls of the same age showed no preference, and our experimentals, whether trained to the plain or painted model, preferred the painted model. This result justifies the treatment of the two testing procedures, rotating or moving models, as equivalent.

In the second experiment we explored the role of simulated visual flicker as a relevant stimulus by means of white models painted with vertical or horizontal (or both) black stripes of varying thicknesses (Fig. 2, A and B). However, except for a crosshatched model and a plain white model, the total amount of black present was the same, irrespective of the thickness or disposition of the stripes. A total of 260 ducklings were used, 20 in each group. Vertical broad and narrow stripes were not discriminated; a plain white and a vertical, narrow-striped model were not discriminated, nor was a plain white and a horizontal narrow-striped model. The crosshatched and plain models were discriminated, however: the ducklings clearly preferred their original training model. Vertical narrow and horizontal narrow stripes were not discriminated.

In the third experiment we examined the influence of color (Fig. 3). One model was plain white, another was a flat red, approximately 6 *pa* on the Ostwald scheme, the third a flat yellow, 1 *pa* (*Color Harmony Manual*, Container Corporation of America, 1948). These two are the colors chicks prefer most and least, according to Schaefer and Hess (*3*) in their study of imprinting preferences. The ducklings discriminated red and yellow, and they selected the color of their training model. No difference in the effectiveness of the two colors was evident. Red, the preferred color according to Schaefer and Hess (*3*), was not discriminated from white. There were 120 ducklings, 20 in each group.

The fourth experiment examined color and stripe interactions (Fig. 4). One model was plain white and the other had horizontal narrow red stripes. A slight bias towards the white model was shown by the controls, but both groups of experimentals selected their training model. There were 60 ducklings, 20 in each group.

Comparisons cannot be made between groups from different experiments or subsets of the same experiment because these groups were run at different times of the year and they were derived from different batches of eggs. There are fairly definite seasonal variations in the vitality of the ducklings; these variations affect the absolute magnitude of their scores, though, presumably, not their relative value. Again, note that while the graphs, for illustrative purposes, show group means, the statistical statements are based upon an appropriate nonparametric test [Wilcoxen matched-pairs sign test (*4*)].

The results fall into three categories, depending upon which models were used. In the first, the ducklings treated the two simultaneously presented models as equivalent, that is, they did not discriminate between them. This was true with combinations of vertically or horizontally striped and plain white models, as well as with the red versus the white model. In the second category the ducklings preferred their orig-

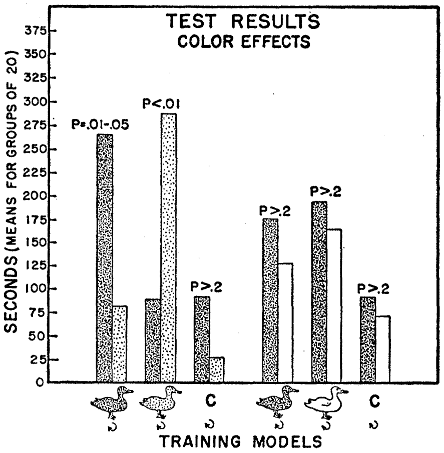

Fig. 3. The role of color in imprinted preferences. Light strippling, yellow; heavy strippling, red.

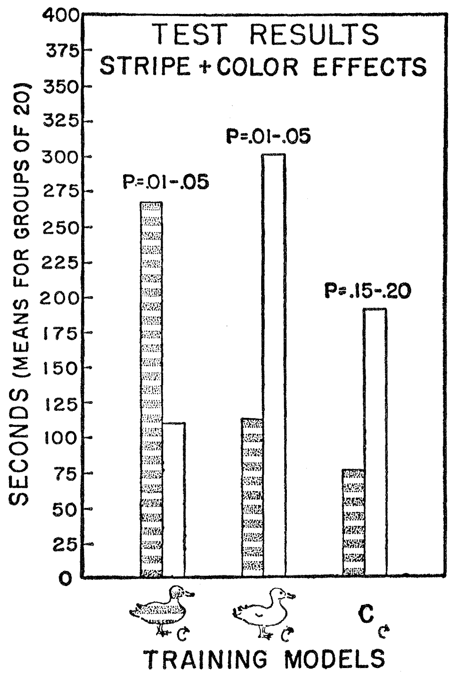

Fig. 4. Interaction of color and stripedness in imprinted preferences.

inal training model, that is, they showed "imprinting." This occurred with the crosshatched and plain, the red and yellow, and again with the red striped and plain white models. And in the third category the ducklings preferred one particular model irrespective of their training model, though the training experience was a necessary prerequisite to this preference. This was similar to our original result, here replicated, with the varicolored and white model.

We do not yet know whether a pair of nondiscriminated models would also be equivalent in a more conventional associative-learning task. It is nonetheless clear that the discriminability or nondiscriminability of the training model is unrelated to its "conspicuousness" in the sense of Bateson (*2*), that is, in the number or disposition of stripes. Nor is it simply related to color: red was not distinguished from white, though red and yellow were distinguished. According to Schaeffer and Hess (*3*), Vantress chicks greatly prefer red over yellow, and white least of all. An interaction is discernible in that the red-striped model was distinguished from a white model, while this was not the case for either an entirely red or black-striped model. This would also seem to preclude flicker effects as the relevant cues.

Let us first assume that models treated as equivalent (the first category) are merely not perceived as different, or only so perceived with difficulty; that is, in a trained discrimination task the ducklings either would never achieve criterion or require substantially more trials to do so than when given two models to which imprinting does occur. If the ducklings do not easily detect black stripes on a white field and only barely distinguish red from white, the results of categories one and two require no separate explanation. However, the results of the third category remain as great an enigma as ever.

We can also assume that the ducklings are, in fact, capable of making learned discriminations as easily between any one pair of models as another. The results of categories one and two then suggest that imprinting is a selective process; that is, it can occur only to certain kinds of models. These models presumably can be ordered along a continuum from those to which imprinting simply cannot occur (category one) through those to which imprinting can occur with equal ease (category two), to those for which an immanent preference exists the expression of which is tied to the imprinting experience (category three). The interesting results of Gottlieb (*5*), who examined preferences for and imprinting to acoustic stimuli, also lend themselves to such a scheme.

These results require that students of imprinting devote at least some of their energies to a more thorough analysis of the characteristics of their imprinting surrogates, as perceived by their subjects, as well as studies of their discriminability under other conditions. The phenomenon of imprinting cannot be elicited with any set of stimuli. Our present results suggest imprinting is far more complex a process than originally suggested by the *tabula rasa* model.

PETER H. KLOPFER
Department of Zoology,
Duke University,
Durham, North Carolina

References and Notes

1. P. H. Klopfer and J. P. Hailman, *Z. Tierpsychol.* **21**, 755 (1964); ———, *Science* **145**, 1333 (1964); P. H. Klopfer, *ibid.* **147**, 302 (1965); ———, *Behav. Sci.* **12**, 122 (1967).
2. P. P. G. Bateson, *Biol. Rev.* **41**, 177 (1966).
3. H. H. Schaefer and E. H. Hess, *Z. Tierpsychol.* **16**, 161 (1959).
4. M. W. Tate and R. C. Clelland. *Nonparametric and Shortcut Statistics* (Interstate, Danville, Ill., 1957).
5. G. Gottlieb, *J. Comp. Physiol. Psych.* **59**, 345 (1965).
6. I thank J. Potter and C. Dewey for assistance. Supported by NIH grant No. MH04453 and a career development award to P.H.K.

3 February 1967

Permanence of Retrograde Amnesia Produced by Electroconvulsive Shock

Reappearance of an avoidance response previously abolished or attenuated by electroconvulsive shock (ECS) has been demonstrated by Zinkin and Miller (*1*) with repeated testing of convulsed animals. The authors therefore question the permanence of ECS-produced retrograde amnesia.

Although few have explicitly tested the assumption of the permanence of amnesia, Zinkin and Miller appear to have examined only the effect of repeated exposures to the experimental situation on retrograde amnesia, and therefore they have not directly tested the permanence of the phenomenon. To directly examine the stability of ECS-produced amnesia, repeatedly tested, convulsed animals must be compared with subjects that are tested for the first time at an interval (after ECS) equal to that at which the repeatedly tested animals receive their last test (in Zinkin and Miller's study this would be at 72 hours, when the repeatedly tested subjects evidenced apparent recovery from amnesia). In this way the permanence of interference with memory can be separated from the performance effects of repeated exposure to the situation in which the original learning took place.

We administered ECS to groups of mice within 75 seconds of a single appetitive or aversive learning trial in the same apparatus, a chamber with a cul-de-sac into which a mouse could poke its head to receive either water or shock from a drinking cup (*2*). Half the animals were tested repeatedly; the amnesia which they evidenced on the first test day, 24 hours after reinforcement and ECS, had largely disappeared on two subsequent retention tests (at 48 and 72 hours) for both appetitive and aversive groups. However, true recovery may not have occurred since the changes in behavior suggestive of recovery from amnesia were similar to those observed in reinforced and nonreinforced control groups, reflecting, in part, gradual adaptation to the experimental situation after repeated exposures. The remainder of the animals, tested for the first time at 72 hours, however, showed degrees of retrograde amnesia equal to or greater than that observed in the subjects tested for the first time at 24 hours. This observation appears to indicate that re-exposure to the experimental situation