The question then arises as to whether a consumer will learn to recognize, and to like or dislike, the flavor upon further or repeated consumption of irradiated beef products. To test this potential of recognition, a panel of 40 consumer-type subjects was requested to rate nonirradiated and irradiated ground beef on 4 successive days and again on the 16th and the 23rd days from the start of the test. In each test session each subject rated two nonirradiated samples and two samples irradiated at a level of 4.0 megarad; all samples were identified only as "ground beef."

The mean preference ratings obtained are shown in Table 2; for statistical analyses, only the data from the 28 subjects who participated on each of the first 4 days were included. Again, a high level of irradiation is shown to decrease consumer preference to a significant extent. There was no significant difference between the ratings given either the nonirradiated or the irradiated samples on any single day, however, and no change was evident in people's preferences in regard to irradiated beef with repeated exposure to the product. Although too few subjects ($N = 18$) participated in all of the sessions for an analysis of variance for the 16th and 23rd days to be conclusive, the data suggest that there was less difference in the preferences between nonirradiated and irradiated samples at the end of the test than at the beginning.

The results in the experiments discussed here suggest that the view that irradiated foods have objectionable flavors is not wholly justified. It seems probable that an attitude of suspicion toward anything connected with irradiation, coupled with the noticeable change in flavor, accounts for the opinion. An analogous evaluation situation would be the attempt to obtain a meaningful flavor evaluation for a canned orange juice with a panel of judges who traditionally drink fresh orange juice and interpretation of their evaluations by the staff of a manufacturer of frozen orange juice.

While it is true that the responses of a representative tasting panel may foretell the influence of attitude upon consumer acceptance, it should be remembered that attitudes change and that it will be several years before irradiated foods are offered to the public. It seems more meaningful at this time, therefore, to recognize that irradiation produces changes in flavor but that such changes are not necessarily objectionable (*4*).

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4. The assistance of participating scientists and laboratories in carrying out the cooperative study is gratefully acknowledged. This report is paper No. 2054 in a series approved for publication. The views and conclusions are ours.

4 June 1960

## Control of Behavior by Presentation of an Imprinted Stimulus

*Abstract.* When presentation of an imprinted stimulus is contingent upon an arbitrarily chosen response, the rate of emission of this response increases. This control of responding requires a moving imprinted stimulus and does not require a following response by the duck.

Imprinting has been described as "the process by which certain stimuli become capable of eliciting certain 'innate' behavior patterns [during] a critical period of the animal's behavioral development" (*1*). In particular, ducklings have been observed to follow moving objects and to develop a lifelong affinity for the followed object. The experiments reported here (*2*) demonstrate that control of the duckling's behavior by the presentation of the imprinted stimulus is not limited to the elicitation of innate responses. The presentation of the imprinted stimulus will also control the rate of emission of an arbitrarily chosen response.

The experimental space was a rectangular, black plywood box divided by a Plexiglas panel into a runway that contained the duck and an apparatus compartment that contained the imprinting stimulus, a yellow cylinder (Fig. 1). "Presentation" of the stimulus consisted of transilluminating it and lighting the dark apparatus compartment. The imprinting stimulus was moved continuously back and forth along the runway, with a slight swaying and twisting motion, at 1 ft/sec. The response chosen for study was a peck of 8 gm or more on a Plexiglas disk 0.75 in. in diameter. This manipulandum (response key) was mounted on the wall of the runway opposite the dividing panel, at a suitable height (3 to 8 in.). White noise and dim illumination were always present in the runway; neither food nor water was ever present.

Two species of duck, Black (*Anas rubripes tristis*) and Peking (*A. platyrhynchous*), were employed in sessions lasting from 1 to 12 hours; similar results were obtained with the two species. The ducks were housed in individual cages a few hours after hatching and were given continuous access to food and water. Each duck was placed in the runway, and the imprinting stimulus was presented for six 45-minute periods distributed throughout the duck's first and second days of life. All of the ducks were observed to follow the moving stimulus closely by the end of the second day.

When the presentation of the imprinted stimulus is contingent on a selected response, the rate of emission of this response increases. Figure 2 shows the sustained rate of pecking by a 3-day-old duck when the imprinted stimulus was presented for 40 seconds after every eighth response. No appreciable decline in the rate of responding after 12 hours of conditioning and 750 reinforcements is observed (the reduction in the rate of responding in the portion of the record marked *a* was correlated with a temporary equipment failure: the imprinted stimulus did not move when presented).

The performance shown in Fig. 2 was obtained with the following procedure: After the final imprinting session, the peck response was conditioned by making presentation of the imprinted stimulus contingent upon responses that increasingly approximated pecking. The response requirement was then gradually increased over a 75-minute period until every eighth response produced the imprinted stimulus. The imprinted stimulus may properly be called a reinforcer (*3*, p. 731) since it increases the rate of a response which produces it. However, the imprinted stimulus differs from other reinforcers, such as food and water, in its control of pecking in that the rate of responding was not observed to decline after a large number of reinforcements.

The rate of emission of responses that produce the imprinted stimulus was brought under the control of a

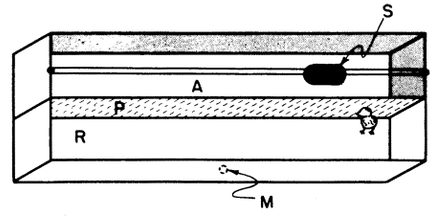


Fig. 1. Experimental space for the control of responding by means of an imprinted stimulus. A plywood box is divided by a Plexiglas panel (*P*) into a runway (*R*) (8 by 1.5 by 1.5 ft) and an apparatus compartment (*A*) (8 by 1 by 1.5 ft). The imprinting stimulus (*S*) is a transilluminated yellow cylinder (4 by 8 in.). The manipulandum (*M*) is a 0.75-in. Plexiglas disk.

discriminative stimulus. Under one condition the response key was transilluminated and reinforcement was contingent upon the completion of ten pecks. Under a second condition the key was darkened and reinforcement was contingent on at least 1 minute of no response. These conditions were alternated, and each condition was terminated by a reinforcement. After 4 hours of training on this multiple schedule of reinforcement (*3*, p. 729) the duck responded during presentation of the stimulus that accompanied reinforcement for responding and did not respond during the presentation of the stimulus that accompanied reinforcement for not responding.

A response was conditioned that was incompatible with the response of following the imprinted stimulus. A transparent key that enabled the duck to see the imprinted stimulus while responding was mounted midway along the Plexiglas wall. The imprinted stimulus was presented for 1 second after each response. Although this brief presentation was too short to permit the following response, a high rate of pecking was sustained. This finding suggests that the following response is not necessary for presentation of the imprinted stimulus to function as a reinforcer.

To show that the pecking response was not maintained solely by the change in illumination concurrent with presentation of the imprinted stimulus, an attempt was made to sustain responding when the reinforcement consisted only of a change in illumination. First, a stable rate of pecking was obtained by presenting the imprinted stimulus after every tenth response (Fig. 3). At point *a*, the moving stimulus was removed from the apparatus compartment and only the change in illumination was contingent upon responding. The rate of responding declined rapidly, and no responses were emitted for several sessions. At point *b* the schedule of reinforcement was adjusted so that each response, rather than every tenth response, produced the change in illumination. The lights in the apparatus compartment were then turned on for 1 minute. Figure 3 shows that this operation did not initiate responding. The moving stimulus was replaced in the box and, at point *c*, the lights in the apparatus compartment were again turned on for 1 minute. After the reintroduction of the imprinted stimulus, the duck began to peck. The rate of responding continued to rise during the next hour.

The reinforcer in these experiments comprised a complex of events including a change in illumination, presentation of the moving stimulus, and following by the duck. The findings reported above suggest that following is not a necessary component of the reinforcement but that the imprinted stimulus is.

Another experiment showed that the imprinted stimulus must be moving in order to control the rate of responding. A stable rate of pecking was obtained by presenting the imprinted stimulus after every tenth response. When the apparatus was adjusted so that the imprinted stimulus no longer moved during presentation, the rate of responding fell rapidly to zero. The pecking response was obtained again on the following day by reintroduction of the moving stimulus.

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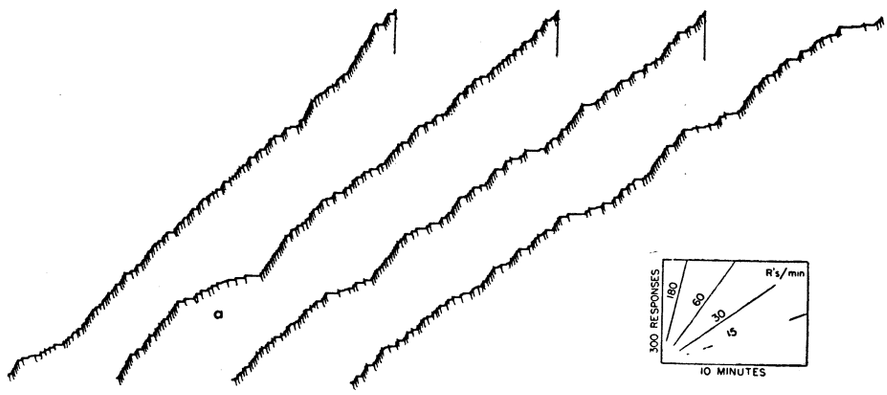


Fig. 2. Rate of pecking by a 3-day-old duck. Each diagonal mark represents a 40-second presentation of the imprinted stimulus after every eighth response (time was not recorded on the abscissa during the presentation of the stimulus). The duck received 750 reinforcements in 12 hours.

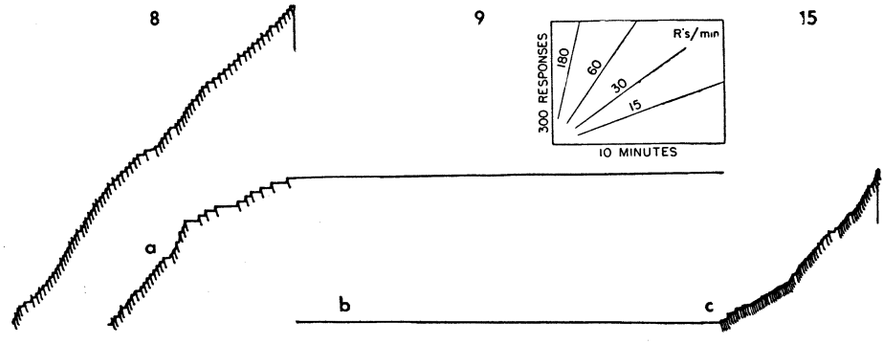


Fig. 3. Records of pecking by a 3-day-old duck. The first record (session 8) shows the rate of responding when the imprinted stimulus was presented after every tenth response. In session 9 the moving stimulus was removed at *a*, and every eighth response produced only a change in illumination. In session 15 illumination was contingent on each response; at *b* the apparatus compartment was lit for 1 minute. At *c* the imprinted stimulus was presented for 1 minute, and reinforcement was then contingent on each response.

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14 June 1960

## Color Phenomena

*Abstract.* A procedure is described which leads to reports of hues for two black figures, one of which is shadowed. Typically, the shadowed figure is seen as blue, the other as black.

If two properly spaced circles drawn in India ink on a white card are placed in a stereoscope so that on fusion two concentric circles are seen, then the circle presented to a red-filtered eye typically appears blue or blue-green and the circle presented to the nonfiltered eye typically appears dark red (*1*). While I was looking through the stereoscope, with the red filter accidentally removed, it appeared to me that one circle was blue and the other green.