Table 1. Radioactivities of products in the digest of 1-C^{14}-amylotriose with crystalline salivary amylase.

Compound	0 hr (counts/min)	6 hr (counts/min)	24 hr (counts/min)
Glucose	8	185	366
Maltose	4	156	226
Amylotriose	692	350	107

glucose and nonradioactive maltose, while hydrolysis of the bond nearest the nonreducing end leads to the formation of nonradioactive glucose and radioactive maltose. Since the radioactivity of the glucose produced from 1-C^{14}-amylotriose was consistently higher than that of the maltose, a faster rate of hydrolysis is indicated for the glucosidic bond nearest the reducing end. It is generally believed that alpha amylase action on starch and starchlike compounds proceeds from both the reducing and the nonreducing end of the molecule. These results support this type of action pattern for salivary amylase.

References and Notes

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Method for Tracing Dark Adaptation in the Pigeon

Donald S. Blough

Harvard University, Cambridge, Massachusetts

Animal subjects are not often used in psychophysical research, because they cannot follow complex instructions or report verbally what they see or hear. The method described in this paper represents an attempt to overcome these difficulties and to obtain with animals some of the efficiency and control that human subjects provide. The method owes much to the work of Skinner and his associates (*1*) and to Békésy's method of human audiometry (*2*). The procedure outlined here is designed for the study of dark adaptation in the pigeon (*3*), but, with modifications, it may be applied to a variety of animal discrimination problems.

Automatic apparatus is used. It includes the following items: (i) a light-tight adaptation box, containing pigeon, response keys, food magazine, and stimulus patch; (ii) a network of relays and timers that control the stimulus luminance and the presentation of food; (iii) a light source and an optical system, with a device that continuously records the stimulus luminance.

A panel divides the adaptation box into two chambers. The bird is trained to stand in one chamber and place its head through a round hole in the panel (Fig. 1). The bird faces a small window through which it views a stimulus patch, 1 cm in diameter, 4 cm beyond the frame of the window. The only light in the adaptation box comes from this stimulus patch. There are two small response keys, *A* and *B*, just below the window. Each peck on one of these keys momentarily opens a switch that is connected with the controlling relay network. When the bird is to be rewarded, a solenoid raises a magazine containing grain to an opening in the floor below the response keys.

The stimulus patch is illuminated from behind by a beam of light. A motor-driven optical wedge in the path of the light beam regulates the luminance of the patch. A shutter may be closed to black out the stimulus patch completely. The movements of both the wedge and the shutter are controlled through the relay network.

The pigeon's basic task is to peck key *A* when the stimulus patch is visible and to peck key *B* when the patch is dark. Training on this discrimination proceeds in several stages. When the bird becomes proficient at one stage, the next stage is introduced; 50 training hours may be needed before experimental data can be collected.

First, the hungry bird (70 to 80 percent of free-feeding cage weight) is trained to peck the two keys at random by the "response differentiation" technique described by Ferster (*4*). Next, the stimulus patch is illuminated, and the control circuit is so adjusted that a peck on key *A* closes the shutter, blacking out the patch. After a peck on key *A* has blacked out the patch, a peck on key *B* causes the food magazine to be raised within reach for about 5 sec. Pecks on key *B* are useless when the patch is lighted, and pecks

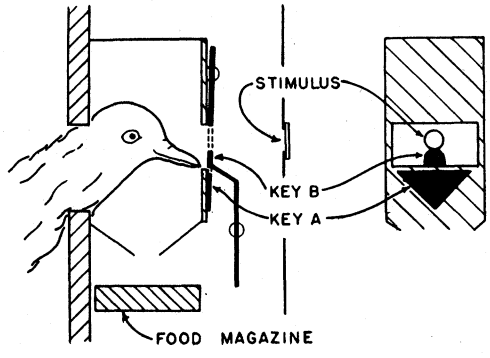

Fig. 1. Response chamber of the adaptation box. (Left) Side view, showing relative positions of pigeon, food magazine, response keys, and stimulus patch. (Right) Keys *A* and *B* and patch seen from the pigeon's position.

on key *A* are useless when the patch is dark. After most rewards, the shutter opens, and the lighted patch reappears. Continued darkness follows one reward in five; in this case, a peck on key *B* brings food a second time. These double rewards train the bird to attend to the stimulus patch after eating; without them, the bird would always peck key *A* after eating, regardless of the condition of the stimulus patch.

In the next stage of training, several pecks in a row, rather than a single peck, are required on key *A* to close the shutter and on key *B* to obtain food. The number of pecks required is varied randomly between one and eight. This increases the time between rewards and prevents the bird from getting a reward simply by pecking the two keys alternately, without attending to the stimulus patch. The time between rewards is further increased by introducing an interval after each reward during which no amount of pecking can close the shutter. The duration of this interval varies randomly about a mean of 7 sec.

When training is nearly complete, a final feature is added to the procedure: the luminance of the stimulus patch is put under the control of the bird's responses during the intervals between rewards. Each peck on key *A* reduces the luminance of the patch by a small amount, while each peck on key *B* increases the luminance of the patch. A pen continuously records these luminance changes. When the bird has learned to perform consistently under these conditions, the collection of threshold data can begin. Experimentation continues indefinitely without further alteration of procedure.

An account of a typical experimental session will serve to illustrate how the bird's threshold is traced. At first, the stimulus patch is brightly lighted, and the trained bird pecks only key *A*. The bird continues to peck key *A* until the patch becomes so dim that it falls below the bird's absolute threshold. Because the pigeon cannot distinguish this "dim-out" of the patch from the true "black-out" caused by the closing shutter, it begins to peck key *B*. But pecking key *B* increases the luminance of the patch, so in a short time the patch again becomes visible to the bird.

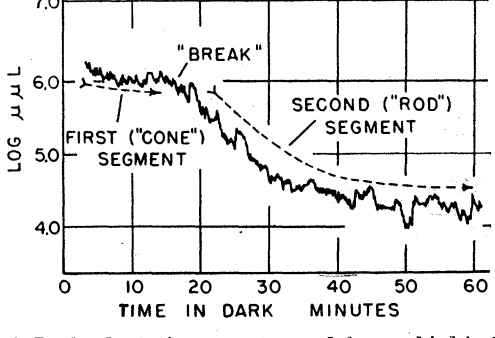

Fig. 2. Dark-adaptation curve secured from a bird in 1 hr. The luminance of the stimulus patch, in log micromicrolamberts, is on the ordinate.

When this happens, the bird switches its pecking back to key *A*, causing the stimulus to dim and to disappear as before. This process continues indefinitely; the bird alternately pecks keys *A* and *B*, and the stimulus fluctuates up and down across the bird's absolute threshold. The continuous record of the stimulus luminance traces the bird's absolute threshold through time. The randomly spaced rewards, when pecks on key *A* close the shutter and pecks on key *B* bring food, interrupt the continuity of this threshold record frequently but for only a few seconds.

During the first portion of an experimental session, the recording pen traces the pigeon's dark-adaptation curve. A reproduction of such a curve in a 1-hr session is shown on appropriate coordinates in Fig. 2. Before this particular session, the bird had spent 1 hr in darkness, followed by 10 min in a box with white walls at a luminance of 22 millilamberts.

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Chromatographic Separation of Polybromo Fatty Esters

David R. Howton

Atomic Energy Project, School of Medicine, University of California, Los Angeles

It was observed some time ago in connection with the preparation of certain carboxy-labeled fatty acids (*1*) that 1-bromoheptadecane is rapidly eluted from alumina by petroleum ether while 1,8,9,11,12-pentabromoheptadecane is not. An order of magnitude of affinity between vicinal pairs of bromine substituents and the hydrogen-bond-contributing type of adsorbent (such as alumina or silica) that had not been appreciated previously was thus revealed; it occurred to us that this observation might be the basis for a new approach to the problem of separating fatty acids differing in degree of unsaturation (*2*).

Recent studies (*3*) have shown clearly that the ease with which fatty acid esters are eluted from alumina or silica columns is an inverse function of the number of carbon-carbon double bonds that they contain; but the separations achieved are at best fair and the yields of pure constituents recovered are poor, reflecting a small contribution of the olefinic centers to the overall adsorption affinity of such substances. (In these studies, as well as in our own, the strongly polar carboxyl group of the free fatty acids is esterified in