The fact that complex cells either do not adapt or, if they do adapt, recover much faster than simple cells is not easy to reconcile with Hubel and Wiesel's hypothesis.

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Stimulus Change Contemporaneous with Food Presentation Maintains Responding in the Presence of Free Food

Abstract. *The presence or absence of a change in the ambient stimulus conditions upon entry into a food source controlled the frequency with which pigeons choose one of two concurrently available grain sources. Such changes characteristically accompany the production of response-produced food and account for prior reports of responding to produce food in the presence of freely available food.*

Several experiments (*1–4*) demonstrate that rats and pigeons acquire and continue to emit food-producing responses in the presence of freely available food. For example, Neuringer (*3*) showed that experimentally naive pigeons would acquire a new food-producing response in the presence of freely available food. Since many theories of learning assume that deprivation is a necessary antecedent of performance (*5*), these results are of substantial interest.

The two experiments presented here show that responding in the presence of free food need not be attributed to the "intrinsic appeal" of food-producing responses (*2*) nor does the "act of producing food" appear to have any special motivational properties (*3*). Rather, responding in the presence of free food is maintained by the externally produced stimulus change which characteristically accompanies the presentation of response-produced food but which does not typically occur during the consumption of free food.

In experiment 1, two White Carneaux pigeons (1411 and 2769) with varied experimental histories were placed in a chamber 38 cm high, 31 cm wide, and 31 cm long. Prior to the experiment both pigeons were allowed to feed freely in their home cages for several days. The chamber contained a response disk (1.9 cm in diameter), a Gerbrands food hopper mounted on one wall, and a filled food cup mounted on the opposite wall. Water and grit were freely available at all times. A photocell and its light source were mounted over the free-food cup (*6*). For the first six 24-hour sessions a single peck to the illuminated response disk allowed the pigeon to eat grain from the hopper for 3 seconds; the bird could also eat from the free-food cup. Pecks to the disk illuminated the grain hopper, turned off the light which illuminated the response disk, turned out the house light which provided general illumination to the chamber, and produced the grain hopper with an audible click. Entries into the free-food cup produced no stimulus change. For the next six sessions, pecks to the response disk produced access to the grain hopper but no other changes in the ambient stimulus conditions (the grain hopper remained continuously illuminated). Entries into the free-food cup turned on a light over the free-food cup, turned the house light off, and produced an audible click by a solenoid behind the free-food cup. For the last six sessions (12 sessions for pigeon 1411), the original conditions were reinstated.

The number of pecks made to the response disk during each session of the three conditions is presented in Fig. 1. Responding was maintained in the first and last conditions when pecks produced both food and stimulus change. However, responding was not maintained when pecks produced only food and entries into the free-food cup provided food and stimulus change.

In experiment 2, the effect of stimulus change associated with one of two free-food sources was studied. Four experimentally naive White Carneaux pigeons (B-17, B-18, B-19, and B-20) were employed. Each pigeon was placed in a chamber 27.5 cm high, 25.0 cm wide, and 30.0 cm long. Rectangular openings on opposite side walls permitted access to the two free-food cups. Throughout the experiment, grain was only available during the experimental sessions and water and grit were only available in the home cage. During the first experimental condition the right food cup was constantly illuminated. Entries into the right food cup produced no stimulus change. Entries into the left food cup turned on a light over the cup, turned off the house light, and produced an audible click by a solenoid. This condition was in effect for a minimum of 20 1.5-hour sessions and until five consecutive sessions occurred with no apparent directional trend. A limit of 50 sessions was set for any case in which stability was not achieved in fewer sessions. After stability was achieved, the conditions were reversed. This condition was also in effect until the criteria described

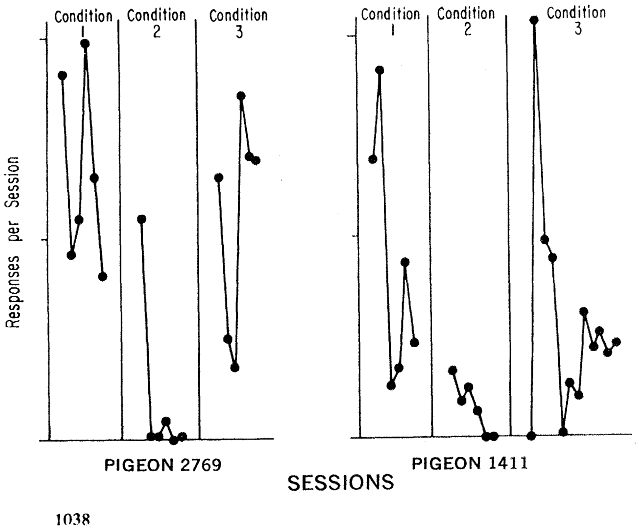

Fig. 1. Responses per 24-hour session for two White Carneaux pigeons (1411 and 2769). In conditions 1 and 3, responses produced food plus stimulus change. In condition 2, responses produced only food and entries into the free-food cup produced stimulus change.

for the first condition were satisfied.

Table 1. Average preference for the food cup with accompanying stimulus change for the last five sessions of each condition, left (L) and right (R).

Pigeons	Food cup	Entries (%)	Time in each cup (%)	Grain consumption (%)	Number of sessions
B-17	L	72	49	63	20
	R	60	25	29	21
B-18	L	33*	30*	27*	50*
B-19	L	61	59	39	20
	R	59	41	43	38
B-20	L	76	78	73	21
	R	56	56	46	21

* Average for sessions 46 to 50. Not stable data.

Three of the four pigeons (B-17, B-19, and B-20) preferred the free-food cup with the accompanying stimulus change in terms of percentage of entries made (Table 1). However, the percentage of time spent in each food cup and the percentage of grain consumed from each cup did not change systematically with the location of the stimulus change. The fourth pigeon (B-18) did not demonstrate a stable preference, but tended to change his preference from side to side in a cyclic pattern across several sessions. This subject was dropped from the study after reaching the 50-session maximum without satisfying the stability criteria.

The data from experiment 1 show that responding in the presence of free food is maintained by the stimulus change which accompanies response-produced food, but which, in previous studies, has never accompanied the consumption of free food. Responding not being maintained when no stimulus change occurred with the response-produced food suggests that responses which produce food have no special intrinsic appeal or motivational properties.

Experiment 2 supports the conclusion that responding in the presence of free food is maintained by the stimulus changes which accompany the arrival of response-produced food by showing that preference for a particular free-food source can be manipulated by stimulus change. Because entry was required to produce the stimulus change, entries, but not time or consumption, changed systematically with the location of the stimulus change. This further supports the contention that the stimulus change controlled the observed preferences.

Neuringer (*3*) demonstrated that stimulus change, alone, was not sufficient to explain this phenomenon. He allowed two pigeons (which had been responding in the presence of free food) to produce the stimulus change but prevented them from consuming any response-produced grain. Both ceased pecking at the disk and ate exclusively from the free-food cup. While this manipulation showed that stimulus change would not maintain response, it did so by severing the association between stimulus change and food. In the two studies presented here we investigated the role of stimulus change without terminating the relationship between stimulus change and food and showed that responding is maintained by stimulus change accompanying food. Stimulus change in this context may be a conditioned reinforcer due to its temporal pairing with food (*7*). The results are also consistent with Herrnstein and Loveland's (*8*) recent position that the presence of food in a procedure enhances the reinforcing effectiveness of stimulus change. In any case, the relationship between stimulus change and food is apparently the crucial factor in maintaining responding in the presence of free food.

The assumption that deprivation is a necessary antecedent of performance is an essential constituent of many learning theories. This assumption may require modification in light of the present results. These results, however, offer no problem for those who define reinforcers (rewards) in terms of their effects on behavior and without reference to inferred internal states (for example, deprivation). The major finding of these experiments is that food-producing responses have no special motivational properties. The phenomenon of responding in the presence of free food, while replicable, need not be construed as an indictment of reinforcement theory. Instead, these responses, like other operant (instrumental) responses, appear to be controlled by their associated consequences.

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Long-Term Sensitization of a Defensive Withdrawal Reflex in Aplysia

Abstract. *When a weak tactile stimulus is applied to the siphon of* Aplysia californica, *the animal withdraws the siphon between the parapodia. This defensive withdrawal reflex can be facilitated (sensitized) if the animal is previously given 4 days of training, consisting of four brief noxious stimuli each day. The sensitization of this reflex can last for up to 3 weeks after training and is mediated by the abdominal ganglion which also mediates long-term habituation. This preparation may provide a system for analyzing the neural mechanism of long-term behavioral modifications of complexity which is intermediate between habituation and associative learning.*

The defensive reflex of siphon and gill withdrawal in *Aplysia californica* (*1*) has been used to study cellular mechanisms of several short-term behavioral modifications (*2, 3*). Long-term habituation of this reflex, lasting several weeks, has been described (*4*). We now report long-term sensitization of the siphon withdrawal component of this reflex.

Sensitization is an elementary form of learning in which reward or punishment facilitates an animal's preexisting response to another stimulus (*5*). While