

BRIEF REPORT

Food-Aversion Conditioning in Japanese Monkeys (*Macaca fuscata*): Suppression of Key-Pressing¹

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Monkeys were trained in a Skinner box to press a key for standard food pellets on a fixed-ratio 10 schedule for 30 min. When stable responding had been achieved, two novel foods (almond nuts and marshmallows) were introduced. In the conditioning sessions on the odd-number days, pressing a key delivered one of the two novel foods as the to-be-conditioned target food, and each monkey was injected cyclophosphamide (4 mg/kg) intravenously in the home cage 10 min after the end of the session. In the control sessions on the even-number days, the monkeys earned the other food, and were never injected. As the conditioning was repeated, the monkeys eventually stopped key-pressing for the target food in the conditioning sessions, but continued to work for and eat the other food in the control sessions.

Food-aversion conditioning can suppress not only the consummatory response to the target food but also some preceding components of the feeding behavior. The degree to which food aversions suppress the preceding components are different among species, and also dependent on the type of response. For example, in the predatory situation, coyotes

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and wolves stopped killing prey to which they had been aversively conditioned, but rats and ferrets never stopped (Garcia, Rusiniak, & Brett, 1977). However, few experiments have investigated the effects of food-aversion conditioning on the arbitrarily defined instrumental responses as the preceding components. Best, Best, and Ahlers (1971) demonstrated that rats suppressed bar-pressing for a target fluid which had been paired with illness in a situation separate from operant chamber. On the contrary, our previous study (Hasegawa & Matsuzawa, 1981) using Japanese monkeys as subjects revealed that pairing a specific food with poison in the home cage had little effects on key-pressing for the same food or on consuming the same food in an operant situation. The previous study shows that contextual cues can have an important role in food-aversion conditioning in Japanese monkeys, but it remains unclear whether monkeys will suppress operant responding for a target food in the same situation where the food is aversively conditioned. The present experiment investigates how and to what extent instrumental key-pressing for a target food will be suppressed after the food is aversively conditioned in the same context.

The subjects were four male Japanese monkeys (*Macaca fuscata*): M206, M243, M271, and M482, weighing 9.8, 8.6, 7.8, and 6.0 kg, respectively, at the start of the experiment. They were housed individually in their home cages with free access to water. Experimental sessions were conducted in a Skinner box (75 × 75 × 75 cm) containing a response key and a food dish. Stimulus scheduling and response recording were performed with a minicomputer (PDP8F). Key-pressing was also recorded with a Ralph Gerbrand's cumulative recorder. Behavior of each monkey was monitored and recorded with a video cassette recorder. During the experiment, monkeys received three kinds of foods: standard food pellets (1.5 g), almond nuts (1.2 g), and marshmallows (0.5 g). The latter two were designated the target food (to-be-conditioned food) or the control food according to a preference test described later. Cyclophosphamide (Endoxian, Shionogi & Co., Ltd.), one of the commonly used antitumor drugs, was used as an illness-inducing agent. The dosage given the monkeys was 4 mg/kg, which was converted from human therapeutic dosage. At this dose level, the gastrointestinal discomfort (i.e., nausea) inferred from behavior was not so serious as the LiCl (100 mg/kg) injection in the previous study (Hasegawa & Matsuzawa, 1981). No monkeys vomited.

Throughout the experiment, each monkey received restricted amount of standard food pellets every morning (150 g for M206 and M243, 100 g for M271 and M482). A daily experimental session was conducted 6 hr after this morning feeding. The monkeys were first trained to press a key for standard food pellets on a fixed-ratio 10 schedule for 30 min. M271 was slow to begin key-pressing in the initial session, so the session time for this monkey was prolonged to 60 min thereafter. The key was

transilluminated by yellow at the beginning of the session, and became darkened and inoperative after 40 reinforcements. Once each monkey had achieved stable fixed-ratio key-pressing, a preference test for two novel foods was conducted. In this test, each monkey earned an almond nut and a marshmallow alternately instead of the standard food pellet. Although each monkey received the same number of almond nuts and marshmallows, each displayed a preferential consumption of one of the new foods. The more preferred food was designated the target food, and the less preferred one was designated the control food for each monkey. Marshmallows were assigned to the target food and almond nuts were the control food for M206 and M482. Almond nuts were the target food and marshmallows were the control food for M243 and M271. After this test session, several familiarization sessions were conducted in order to assure that monkeys would consume both foods before conditioning.

When each monkey earned and consumed more than 20 pieces of the target food (more than 50% of the maximum amount of food available), he was injected intravenously with cyclophosphamide in the home cage 10 min after the end of the session ("conditioning session" on Day 1). On the next day, key presses delivered the control food, and the monkeys were not injected ("control session" on Day 2). In either case, the key was transilluminated by red in the session when the marshmallows were available, and by green in the session when the almond nuts were available. The key became darkened and inoperative after 40 reinforcements. The conditioning session was repeated every other day (on odd-number days) until each monkey never consumed the target foods or consumed less than five pieces. On the even-number days, he received the control sessions.

Figure 1 shows the consumption of almond nuts and marshmallows in each monkey. The Arabic numerals in the figure represent the number of rewards delivered in the conditioning sessions. With few exceptions, the monkeys ate either food whenever it was delivered. After 5 to 8 conditioning sessions, all monkeys suppressed key-pressing for the target food and consumed less than five pieces of it. On the other hand, the monkeys continued to work for and eat the control food in the control sessions. We introduced two novel foods as "double baseline" within subjects. (One food was designated the target food, and another was the control food in the same context within subjects.) We showed that both key-pressing and consummatory response were suppressed only in the target food with aversive consequences. The suppressive effect did not transfer to the control food in the same context. The constant eating of the control food suggests that the suppressive effect on the target food was due to neither a general intake suppression or enhanced neophobia in the Skinner box, nor a poison-induced debilitation. The suppression of the preceding instrumental response for the target food shown in this

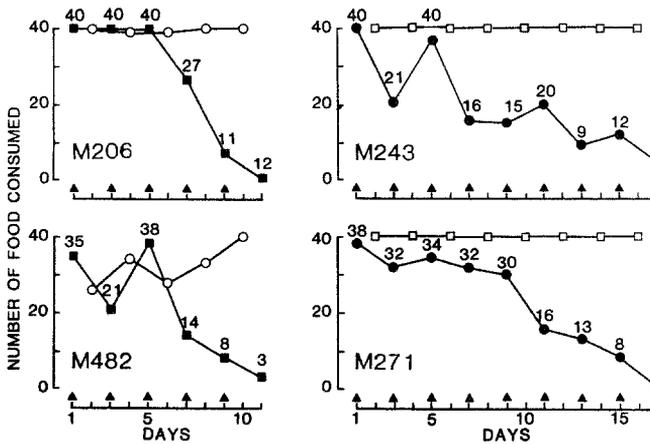


FIG. 1. Food consumption for each monkey in the conditioning sessions (on odd-numbered days) and in the control sessions (on even-numbered days). Arabic numerals represent the number of rewards delivered by key-pressing. ■, Target food (marshmallows); ●, target food (almond nuts); □, control food (marshmallows); ○, control food (almond nuts); ▲, cyclophosphamide injection.

study is congruent with Sjöden and Söderberg (1981), who reported the similar effect on bar-pressing for saccharin solution in rats.

We examine the suppressive effects on the instrumental key-pressing in detail. As the conditioning was repeated, key-pressing for the target food decreased especially in the later part of the daily session. Figure 2 shows the cumulative records of key-pressing in the last conditioning session and in the last control session. Overall rate of responding was quite different between the target and the control conditions, while local rate of responding (the response rate in the bout of key-pressing) fulfilling the fixed-ratio requirement was always constant. Similar data were obtained by Treadway (1976) using rats as subject. Both data indicate that the food-aversion conditioning does not affect the local rate of operant responding maintained by fixed-ratio schedule. The marked difference between the two conditions was due to the prolonged postreinforcement pause shown in the conditioning session. When the target food was delivered, monkeys hesitated to take it out from the food tray, walking around in the box, looking into the key, touching the wall, and so on. After eventually taking out the food with hesitation, monkeys sniffed it and stored it temporarily in their cheek pouches before ingestion. They often examined the food by retrieving it again from the pouches, washing it by the hands, tasting, and gnawing off a small piece of it. These behaviors produced an increase in the postreinforcement pause. After several target foods had been delivered and consumed, M243, M271, and M482 never pressed a key till the end of the session. M206, which showed

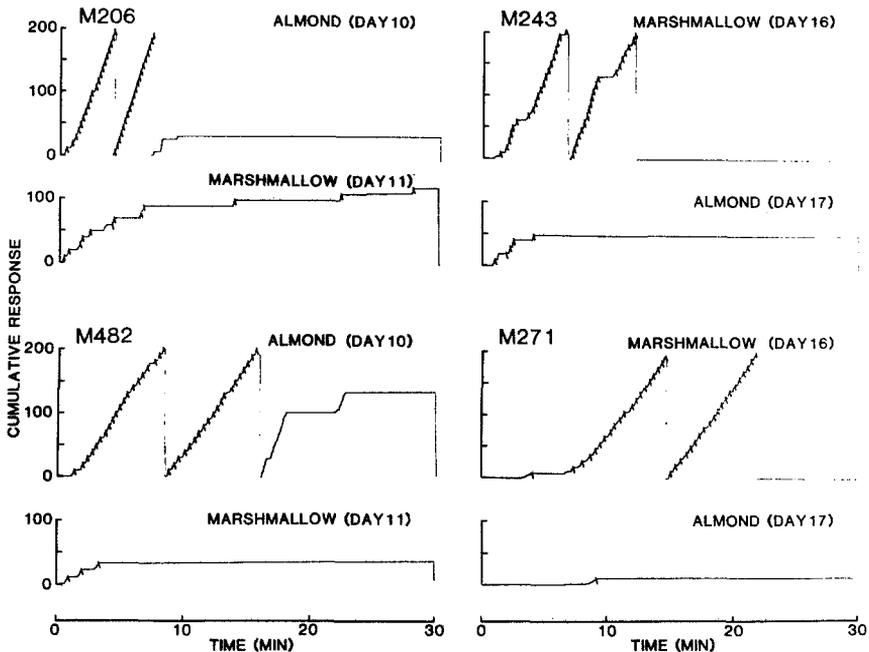


FIG. 2. Cumulative records of key-pressing in each monkey. The upper sections show the records for the control food in the last control session. The lower sections show those for the target food in the last conditioning session.

relatively shorter postreinforcement pause, spilled some pieces of the target food without swallowing them, or refused to take them out from the food tray. The observed behavior of the monkeys in the presence of the target food following conditioning, suggests that not only the proximal food stimulus (taste) but also the distal food stimuli (e.g., odor, sight) have a major effect on the food aversion conditioning. The visual, olfactory, and taste cues might be intermingled to inhibit the consummatory and appetitive instrumental responses. Recent studies using compound cues in food-aversion conditioning revealed the interaction of these cues such as the potentiation of weak distal cues by the combined strong cue (Rusiniak, Hankins, Garcia, & Brett, 1979; Clarke, Westbrook, & Irwin, 1979). Monkeys depend highly on the visual cues to search and get foods in their natural environment. The utilization of such a distal food cue might reduce the risk of tasting poison.

It is possible that the suppression of key-pressing is controlled by the preceding discriminative stimuli. Latencies for the first occurrence of responding shown in Fig. 2 were not different between two conditions in each subject. This indicates that monkeys suppressed key-pressing not because they learned that the conditioning sessions were always conducted on the next day of the control session. This result also denies

the possibility that key color had an important role in the suppression of key-pressing. The key color informed the kind of food available in the session, and the termination of key light was utilized as cue to stop responding at least in two monkeys (M243 and M271). The key color, however, had no controlling effects on the suppression of key-pressing. The failure to utilize those preceding stimuli as cue for responding, makes a contrast to the facts obtained from the other forms of aversive stimulation such as conditioned suppression by electric shock, where time sequence or key colors could have discriminative controlling powers over the operant responding. Monkeys suppressed key-pressing only by the consequence of responding. When the control food was delivered, the monkeys continued to work for it. On the contrary, they stopped responding when the "aversive" food was delivered. These results obtained in this study clearly indicate that food-aversion conditioning to one food can suppress both instrumental and consummatory response to the food in the same context. Moreover, this suppressive effect does not transfer to the different food in the same context.

Key-pressing is the arbitrarily chosen instrumental response, preceding the consummatory phase of the feeding behavior. The suppression of key-pressing in monkeys was discriminatively specific to the food that had been associated with poisoning. Practically speaking, it is possible that food-aversion conditioning serves as a method for controlling the food-collecting behaviors (e.g., stealing fruits from orchards or infesting potato farms) of wild Japanese monkeys, just as it does for controlling predatory behaviors of coyotes or raptors (Brett, Hankins, & Garcia, 1976). Such a program could potentially spare wild monkeys being currently controlled by killing or trapping.

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