

GROOMING MOVEMENTS AS OPERANTS IN THE RAT

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Two experiments investigated the effect of contingent food deliveries on grooming movements in rats. The grooming sequence was divided into three topographically distinct behaviors: paw washing, face washing, and body washing. The first experiment found that rates of paw washing and body washing increased reliably under a food contingency, but face washing did not. A second experiment replicated these findings, and, in addition, showed that the average duration of paw washing and body washing decreased in length when followed by food. Placing a contingency on face washing, however, produced an increase in the rate of paw washing but no increase in face washing. It was concluded that, on the one hand, paw washing and body washing may be influenced by operant contingencies in the same way as behaviors such as lever pressing. On the other hand, increases in paw washing under the face washing contingency suggested that increases in the rate of grooming movements may occur by means other than operant relations.

Key words: constraints on learning, grooming movements, adjunctive behavior, rats

Some recent research has suggested that not all the behaviors of a food-deprived organism can be increased in response rate by contingent food delivery. In a series of experiments, Shettleworth (1973, 1975) attempted to reinforce various naturally occurring behaviors ("action patterns") of golden hamsters with food. Bar pressing, digging, scrabbling, and rearing (see Shettleworth, 1975, for a description of these behaviors) were increased in rate by contingent food whereas face washing, scratching, and scent marking were not.

The failure of an operant contingency to affect the rate of some action patterns has been attributed either to some "biological constraint" on the performance of some action in an operant contingency (Seligman & Hager, 1972) or to the absence in an operant setting of some hypothetical eliciting stimulus for the act (Konorski, 1967). The latter argument has been investigated recently by Pearce, Colwill, and Hall (1978), who attributed the failure of Shettleworth and Konorski to obtain food-contingent rate increases in grooming movements to the absence of grooming-provoking

stimuli. By providing rats with a collar which was assumed to produce a scratch-provoking itch stimulus, Pearce et al. were able to condition scratching successfully with an operant food contingency. The study also provided some evidence for food-contingent rate increases in scratching even in the absence of the collar.

The apparent refractoriness of grooming movements to food contingencies found by Shettleworth (1973, 1975) and Konorski (1967) could also be due to the way grooming was defined. Observation of rats in our own laboratory suggested that the grooming sequences might be divided into three topographically distinct movements: licking paws (paw washing), bringing the paws over the ears and downward over the snout (face washing), and bending the head forward into the belly (body washing). The grooming behavior investigated by Shettleworth (1975) appears most similar to our face washing, and was defined by her as "rubbing forepaw(s) over any part of head; includes interspersed licking of paws." The present investigations were intended to discover whether the failure of a food contingency to increase grooming rate in Shettleworth's study applied to face washing alone or was a general characteristic of grooming movements.

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EXPERIMENT 1

The purpose of the first experiment was to discover if grooming in rats could be affected by contingent food deliveries. To provide some comparison for any changes in grooming which might occur, food deliveries were made contingent on occurrences of two other behaviors (standing and rotating). On the basis of previous work (Shettleworth, 1975), these other behaviors would be expected to be reinforced with food; therefore, any failure to obtain a rate increase with these behaviors would indicate that the present experimental arrangements were unsuitable for providing demonstrations of reinforcement of grooming behaviors.

METHOD

Subjects

Twelve male albino rats, approximately 100 days old at the start of the experiment, were maintained at 80% of their free-feeding body weights.

Apparatus

A single rodent test chamber, without response lever, was used. The subject area measured 27.5 cm long, 15.0 cm deep, and 30.0 cm high. The floor consisted of aluminum rods spaced with centers 1.2 cm apart. The front wall was made from transparent Plexiglas and afforded a clear view of the subject. A light on the rear wall of the chamber provided gen-

eral illumination. Reinforcers were 45-mg food pellets (Campden Instruments Ltd.) delivered into a food tray on the right-hand wall of the chamber. Delivery of a reinforcer was accompanied by the click of the food dispenser. The behaviors were recorded by an observer sitting about 2 m from the test chamber.

Procedure

The experiment consisted of three phases: pretraining, contingent food delivery, and extinction. Two subjects each were assigned to one of six groups. Groups differed according to the behavior on which food was contingent in Phase 2 of the experiment. The behaviors were: standing (S), rotating (R), paw washing (P), body washing (B), face washing (F), or any grooming (A), a condition in which occurrences of either paw washing, body washing, or face washing were followed by food. The detailed definitions of the various behaviors are given in Table 1.

Table 1 also shows the extent of interobserver agreement for the occurrence of behaviors in the various categories. This was computed as follows: starting with the first session of Experiment 1, both observers recorded the occurrence of the target behavior (i.e., that behavior which would be followed by food in Phase 2) independently, but only one of them (A.A.) delivered food. When one observer had recorded 100 instances of a particular behavior, the number of observations recorded at this point by the other observer

Table 1

Definitions of the various behaviors reinforced in Experiments 1 and 2, and interobserver agreements for those behaviors.

| <i>Behavior</i> | <i>Definition</i> | <i>Interobserver agreement (%)</i> |
|-----------------|---|------------------------------------|
| Standing | At least one front paw must touch the chamber wall on or above the level of a line 14.4 cm above the chamber floor. The rat must place at least one front paw on the floor between reinforcers. | 96 |
| Rotating | The rat must turn at least 180 degrees in a clockwise direction in a continuous movement anywhere in the chamber. Any continuous revolution counts as one response. | 94 |
| Paw washing | The paw(s) must be held under the chin and the rat must appear to give the paw(s) at least one lick or bite OR there must be a movement of the paw(s) to the tip of the snout and back. | 89 |
| Face washing | The paw(s) must come over the snout to at least eye level, and be moved over the end of the nose. Each complete stroke counts as one response, regardless of whether one or both paws are used. | 94 |
| Body washing | The rat must appear to lick or bite the belly region, i.e., anywhere between the hind legs. The rat must lift its head between reinforcements. | 92 |

was noted and the agreement value computed. For example, if one observer recorded 100 instances of standing and the other observer only 96 the agreement between observers was 96%, and so on. Since all the agreement values were high, a single observer (A.A.) recorded all behaviors and delivered all reinforcers for the remainder of this experiment and in Experiment 2.

In the first session of pretraining (Phase 1), subjects were merely observed and food was not delivered. In the second pretraining session, subjects were magazine trained until they rapidly approached and ate from the food tray when food was delivered. Care was taken to avoid following the same behavior with a food delivery repeatedly and to avoid the development of any "superstitious" behaviors that might interfere with any changes occurring when food deliveries were response-contingent in Phase 2.

Phase 2 consisted of five sessions in which one of the six target behaviors was followed by food. The target behavior depended on the condition to which the subject had been as-

signed. For example, in Group P (paw washing) individual instances of paw washing meeting the definition given in Table 1 were followed by food deliveries. The only behavior recorded in each session was the behavior followed by food except for subjects in Group A (any grooming). For these subjects paw washing, body washing, and face washing were all recorded.

Phase 3 consisted of two sessions in which food was not delivered. Each session was terminated when either 30 min had elapsed or 100 food pellets had been delivered, whichever came first.

RESULTS AND DISCUSSIONS

Rates of occurrence of each of the target behaviors are shown in Figure 1. Within each condition, the two rats behaved in a consistent manner. Rotating, standing, paw washing, and body washing all increased markedly above pretraining rates when followed by food and declined during extinction. Of the subjects in Group A, in which either paw, face, or body washing was followed by food, one adopted

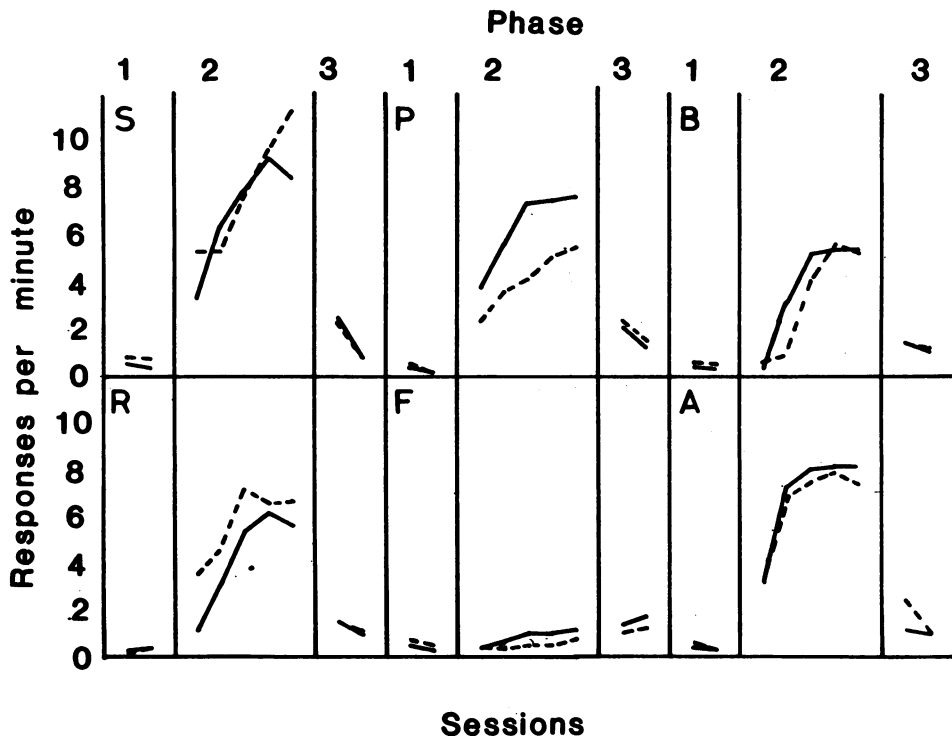


Fig. 1. Response rate data from Experiment 1. Solid lines connect daily session response rates from one of the animals in each group, dotted lines connect rates from the other subject in the group. The behavior on which food was contingent is indicated by the letter shown in the Phase 1 column: S = standing, P = paw washing, B = body washing, R = rotating, F = face washing, and A = any grooming.

almost exclusive paw washing, the other almost exclusive body washing.

Face washing alone did not increase markedly in rate when followed by food, although removal of food did appear to produce some slight increase above pretraining rates.

The above results, while consistent with previous work (e.g., Shettleworth, 1975), suggest that not all types of grooming by rats are refractory to food contingencies. A number of incidental observations are also of interest. When a particular grooming movement increased in rate, it also appeared to become minimal in form (cf. Benninger, Kendall, & Vanderwolf, 1974; Shettleworth, 1973, 1975). For example, paw washing seemed to occur in shorter bouts as it increased in frequency. In addition, casual observation suggested that paw washing increased in rate when face washing was followed by food.

One question that the results of Experiment 1 did not answer is whether the rate increases observed in Phase 2 were due to the contingent relationship between the occurrence of the target behavior and food or as a result of some other factor, such as the elicitation of grooming by food pellets. One way of investigating this is to use a multiple baseline design. In this procedure, a number of different behaviors could be concurrently observed while food delivery is made contingent on one of them. For example, paw washing, body washing, and face washing could all be observed while, for different subjects, only one of the grooming movements would be followed by food. If the grooming movements are generally elicited by food, this procedure should produce a rate increase in all of them.

This design was incorporated into Experiment 2 and a number of other improvements were also made. The period of contingent food delivery was increased from 5 sessions to 10 to provide greater opportunity for slowly developing rate increases to manifest themselves, and the extinction period was also lengthened. In addition, the length of time spent in the various grooming movements (the bout length) was measured.

EXPERIMENT II

METHOD

Subjects

Eight experimentally naive male albino Sprague-Dawley rats, approximately 100 days

old at the start of the experiment, were maintained at 80% of their free-feeding weight for all sessions except the first session of pretraining.

Apparatus

A single observer (A.A.) was equipped with a small keyboard system. Depression of a key caused a cumulative counter located in another room to increment every .2 sec so that the total session time spent performing the various behaviors could be measured and the average session bout length (total time in session spent performing the behavior/number of instances of the behavior) readily computed. In addition, another counter recorded the total number of depressions of the key. This system enabled the observer to simultaneously record occurrences of paw, face, and body washing while delivering a food pellet after one of them. The subjects' chamber and reinforcers were as in Experiment 1.

Procedure

The experiment consisted of three phases: pretraining, contingent food delivery, and extinction. Subjects were randomly assigned to one of three groups, which differed according to the behavior that was followed by food in Phase 2 of the experiment. For two rats, the Phase 2 target behavior was paw washing (21:P and 22:P), for two it was body washing (23:B, 24:B), and for four it was face washing (25:F, 26:F, 27:F, and 28:F).

Pretraining (Phase 1) consisted of three sessions. In the first session, subjects were observed in the chamber at their ad lib body weights. In the second session, subjects were observed at 80% of their free-feeding weights. No pellets were delivered in either of these two sessions. The third session consisted of magazine training, conducted as in Experiment 1.

Phase 2 consisted of 10 sessions in which each occurrence of the target behavior was followed by a food pellet. Criteria for the occurrence of a behavior were as in Experiment 1.

Phase 3 consisted of four sessions in which food pellets were not delivered.

Each session was terminated when either 30 min had elapsed or 100 food pellets had been delivered, whichever came first.

RESULTS AND DISCUSSION

Figure 2 shows the rates of occurrence of paw, body, and face washing, and Figure 3 shows the average bout length of these behaviors. To simplify the figures, the data shown are the rate (or bout length) of the Phase 2 target behavior regardless of its rate, and the rate (or bout length) of any other behavior that occurred more frequently than .5 responses per min during a particular session. Thus behaviors occurring very infrequently are omitted from the figures.

Figure 2 shows that the reinforcement procedure clearly increased the rate of paw washing (Rats 21:P, 22:P) whereas withholding food reversed this effect. Other grooming behaviors occurred so infrequently during the paw washing contingency that they were omitted from the figure.

Body washing showed a similar clear rate increase when followed by food and a decrease

when food was withheld (Rats 23:B, 24:B). Other grooming behaviors which occurred with sufficient frequency to be included in the figure showed no systematic change in rate when body washing was followed by food.

Table 2 presents the rate data for all observed behaviors, including those omitted from the figures, for the last session of each experimental phase and shows that placing an operant contingency on either paw or body washing increased the rate of these behaviors and suppressed other grooming movements. The rates of food delivery in the various conditions are also shown in Table 2 and strongly suggest that the rate increases observed under the paw and body washing contingencies were due to operant reinforcement rather than some other means. For example, in the last session of Phase 2 Rats 21:P and 24:B received similar rates of food delivery, yet their behaviors were quite different. Both subjects showed rate increases in only the behavior on which

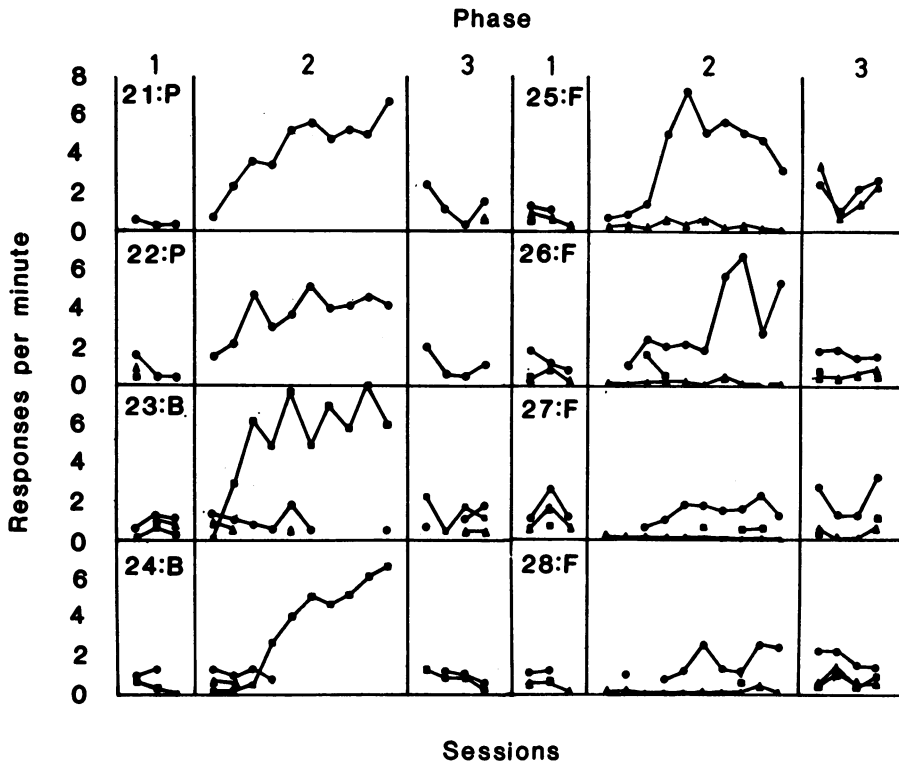


Fig. 2. Daily response rates from Experiment 2. Circles indicate paw washing, triangles indicate face washing, and squares indicate body washing. The behavior on which food was contingent is indicated by the code letter next to each subject's number: P = paw washing, B = body washing, and F = face washing. Behaviors not involved in the contingency are shown only when their rate exceeded 0.5 responses per minute.

Table 2

Rate of each grooming behavior (responses per minute) and rate of pellet delivery (pellets per minute) for the last session of each phase of Experiment 2. No food was delivered during Phase 3.

| Subject* | Phase 1 | | | | Phase 2 | | | | Phase 3 | | |
|----------|-------------|--------------|--------------|-------------------------|-------------|--------------|--------------|-------------------------|-------------|--------------|--------------|
| | Paw washing | Body washing | Face washing | Rate of pellet delivery | Paw washing | Body washing | Face washing | Rate of pellet delivery | Paw washing | Body washing | Face washing |
| 21:P | .40 | .00 | .32 | 4.00 | 6.86 | .14 | .20 | 6.86 | 1.56 | .30 | .90 |
| 22:P | .58 | .21 | .37 | 4.18 | 4.16 | .08 | .00 | 4.16 | 1.10 | .22 | .42 |
| 23:B | 1.15 | .38 | .77 | 2.95 | .53 | 6.05 | .13 | 6.05 | 1.80 | 1.10 | .50 |
| 24:B | .34 | .04 | .11 | 3.78 | .00 | 6.70 | .00 | 6.70 | .59 | .23 | .33 |
| 25:F | .49 | .02 | .36 | 3.26 | 3.13 | .20 | .13 | .13 | 2.70 | .33 | 2.42 |
| 26:F | .78 | .07 | .37 | 3.40 | 5.40 | .37 | .17 | .17 | 1.60 | .55 | .82 |
| 27:F | 1.16 | .15 | .67 | 3.05 | 1.42 | .03 | .03 | .03 | 3.42 | 1.23 | .73 |
| 28:F | .33 | .09 | .21 | 3.04 | 2.52 | .20 | .20 | .20 | 1.53 | .88 | .62 |

*P = paw washing; B = body washing; F = face washing.

food was contingent, strong evidence that paw washing and body washing in these cases were operants reinforced by food.

Making food dependent on face washing (Rats 25:F, 26:F, 27:F, and 28:F) did not increase face washing rates above pretraining levels; if anything, a decrease was evident. Omission of food in Phase 3 did seem to produce a rate increase above Phase 1 and Phase 2 levels, particularly for Rats 25:F and 26:F.

The clearest effect of the face-washing contingency was an increase in paw-washing rates. This was most marked for Rats 25:F and 26:F but was also shown by the other animals. In contrast, body washing showed no such rate increase under the face-washing contingency and generally occurred too infrequently for inclusion in the figure. The increase in paw-washing rates under the face-washing contingency is all the more remarkable in view of the low rates of food provided. Table 2 shows that the rate of paw washing under the face-washing contingency was between 12.6 (Rat 28:F) and 47.3 (Rat 27:F) times the rate of food delivery.

Figure 3 shows bout length data. The bout lengths varied widely across behaviors (body-washing bouts generally being much longer than face-washing bouts, for example); therefore, in order to encompass a large range on the figure, data have been transformed into natural logarithms. The session mean bout length for each included behavior was computed each day, and the natural logarithm of this value is shown in Figure 3.

Reinforcement of paw washing produced a

clear decrease in bout length, an effect reversed by extinction. Reinforcement of body washing also produced a bout length reduction in that behavior, and again the effect was reversed by extinction.

The face-washing contingency appeared to produce a slight decline in the bout length of face washing. However, since face washing occurred with low frequency in this condition, the bout length data were computed from a small number of observations and should be interpreted with caution. The bout lengths of paw washing under the face-washing contingency appeared to be lower than Phase 1 levels, although they were not so low as those seen when paw washing was reinforced in Rats 21:P and 22:P. Removal of the face-washing contingency in Phase 3 produced a slight increase in the bout length of both paw washing and face washing.

GENERAL DISCUSSION

The results of Experiments 1 and 2 suggest that not all aspects of the rat grooming sequence are refractory to food reinforcement. Paw washing and body washing both increased reliably in rate when followed by food and decreased when food was withheld. The alteration in their bout lengths when reinforced also resembles findings with behaviors whose operant status is rarely questioned. For example, Margulies (1961) measured lever-press duration in rats during baseline (no food), reinforcement, and extinction conditions. Response duration decreased under the reinforcement

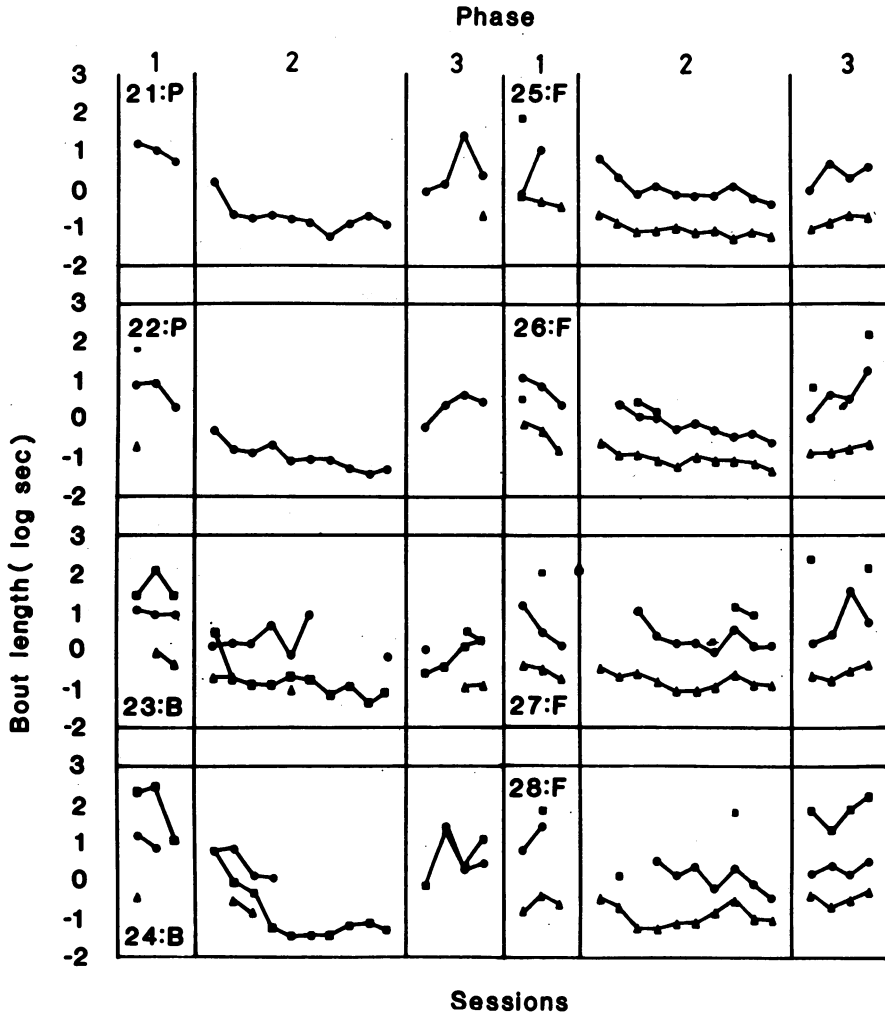


Fig. 3. Daily bout lengths from Experiment 2, expressed as natural logarithms of the average number of seconds spent in each behavior shown in Figure 2. Other details as Figure 2.

contingency and increased again toward baseline levels during extinction. More recently, Schwartz (1977) has catalogued changes in pigeon key-peck durations under reinforcement contingencies.

The effect of the face-washing contingency is more difficult to interpret. Clearly, face-washing rates did not increase under the contingency. At present, the evidence does not support conclusively the belief that there may be some biological constraint on the reinforcement of face washing. First, the technique used in the present study may be in some way faulty. Second, even if food cannot act as a reinforcer for face washing, some other stimulus may do so.

The change in the rate of paw washing under the face-washing contingency may also have parallels in earlier studies. When food is periodically delivered to an animal, whether dependent on a response or not, behaviors not required by the reinforcement contingency often occupy much of the time between reinforcers. Falk (1969) and Staddon (1977), discuss some of these instances of "adjunctive" behavior. The exactness of the analogy between adjunctive behaviors such as schedule-induced polydipsia (Falk, 1969; Staddon, 1977) and the paw washing seen under the face-washing contingency in the present study could perhaps be questioned. First, schedule-induced behaviors have been reported most frequently

from periodic reinforcer deliveries (but see Staddon & Simmelhag, 1971, for an exception). Although the individual interreinforcer times under the face-washing contingency were not measured, they were dependent on the occurrence of face washing, and there is no reason to suppose that this was periodic. Secondly, the rates of food delivery in the face-washing contingencies in the present study are lower than the rates of food which support adjunctive behaviors (Staddon, 1977). Nevertheless, the results of the present study show that paw washing may be increased in rate by the face-washing contingency, and thus suggest that not all rate increases in grooming behaviors need be produced by operant reinforcement. The bout length data suggest that the bout length of paw washing occurring under the face-washing contingency is intermediate between the bout length of that occurring during baseline sessions and that occurring when paw washing is reinforced. Possibly bout length, or some other topographical features, can be used to distinguish operant grooming from that occurring under other conditions. However, it is possible that the short bout lengths occurring when paw washing is reinforced occur simply because bouts are terminated when food is delivered. Since the rate of food deliveries under the face-washing contingency is very low, fewer bouts are truncated by food delivery, leading to a higher mean bout length.

The present results illustrate that some of the movements involved in the rat grooming sequence are affected by operant contingencies in the same way as manipulative movements such as lever pressing. Furthermore, food-contingent rate increases in paw washing

and body washing occur even in the absence of a special stimulating condition imposed to induce these responses.

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