

*OPERANT CONDITIONING OF AUTOGROOMING
IN VERVET MONKEYS
(Cercopithecus aethiops)*

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Vervet monkeys received food reinforcement contingent on autogrooming. Experiment 1 reinforced grooming on a schedule of increasing intermittency and grooming increased in frequency and duration; with only pauses reinforced, grooming decreased in frequency and duration. Experiment 2 demonstrated differentiation of operant autogrooming; in each session a different single form of grooming was reinforced (for example, grooming the tail only), and that form increased in frequency while other forms became less frequent. In Experiment 3 scratching was successfully conditioned with a method that selectively reinforced variety in behavior; reinforcement was contingent on a shift in scratching form. In Experiment 4, with no contingencies on grooming, a prefood stimulus did not increase autogrooming whether or not grooming had previously resulted in contingent reinforcement. The form of conditioned autogrooming resembled the form of unconditioned autogrooming. The discussion suggests how reinforcement principles can account for changes in the topography of operant behavior.

Key words: operant autogrooming, operant scratching, response differentiation, response topography, response variety, resurgence, variable-duration schedule, fixed-duration schedule, vervet monkeys

In selecting exemplars of instrumental or operant behavior, both Thorndike (1911) and Skinner (1938) originally chose biologically neutral responses, with no unconditional relation to the reinforcer (i.e., responses that were not elicited by the reinforcer). In the words of Thorndike (1911), responses should be chosen so that conditioning would proceed without the "helping hand of instinct" (p. 30). After having conditioned arbitrarily selected responses such as latch pulling in cats with food, Thorndike extended the paradigm to more natural patterns of behavior, also with no connection to the reinforcer; for example, in cats autogrooming responses could be conditioned

with food. Lorge (1936) further demonstrated that face washing, standing up, begging, and scratching in rats could be conditioned with food. The view then was that reinforcement works regardless of the biological relevance of the reinforcer for the response and regardless of the specification of the response (Lorge, 1936).

Yet, not all attempts have been successful in conditioning autogrooming and other

We thank the Institute of Neurophysiology, Panum Institute, University of Copenhagen for providing us with space, equipment, and animals. We thank Samuel Charlton, Perrin Cohen, Suzanne Gleeson, Wendon Henton, Cindy Lawler, Sara Shettleworth, and Murray Sidman for comments on different versions of the manuscript.

Portions of the results were presented at the Northeast Regional Meeting of the Animal Behavior Society, Boston, October 1982.

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This research was supported by a research fellowship from the University of Copenhagen to Iver H. Iversen and by fellowships from the European Science Foundation and the Ministry of Nordic Councils to G. Adda Ragnarsdottir. Preparation of the manuscript was supported by a grant from the Danish Research Council for the Humanities to the first author.

The monkeys were acquired and maintained according to the standards set by the Danish Department of Justice and the Danish Committee for Protection of Animal Rights.

naturally occurring activities with no unconditional relation to the selected reinforcer. The constraints-on-learning view (Hinde & Stevenson-Hinde, 1973; Seligman & Hager, 1972) questions whether arbitrarily selected responses accurately represent the set of all conditioned behaviors.

Shettleworth (1975, 1978) and Shettleworth and Juergensen (1980) systematically investigated various combinations of responses and reinforcers. Using golden hamsters, the experimenters attempted to condition behaviors such as open rearing, face washing, scratching, and scent marking with different reinforcers such as food, nest material, or electric stimulation of the lateral hypothalamus. Open rearing could be conditioned with all reinforcers; face washing could be conditioned with brain stimulation and to some extent with food reinforcement; scent marking could not be conditioned with any of the reinforcers. So, for a particular reinforcer, different responses may not condition equally well; for a particular response, however, the extent of conditioning may depend on the selected reinforcer. Several other investigators attempted to condition various grooming forms with food in rodents and in general found increases in frequency and duration of some but not all grooming forms (Annable & Wearden, 1979; Charlton, 1983; Morgan & Nicholas, 1979; Pearce, Colwill, & Hall, 1978; Peden & Liddell, 1983). Using food as the reinforcer, Konorski (1967) conditioned ear scratching in cats, and Hogan (1964) conditioned preening in pigeons; both reported increases in frequency of the selected behavior.

Research with conditioning of naturally occurring activities has shown that the conditioned behavior may drift into a form that does not resemble the initially reinforced response form (Breland & Breland, 1961; Konorski, 1967; Lorge, 1936; Shettleworth, 1973, 1978; Thorndike, 1911). In particular, conditioned grooming and scratching have apparently shown only remote resemblances to the unconditioned forms of these activities in some experiments. The appearance of un-

natural grooming forms, among other findings, has led to suggestions that the law of reinforcement is seriously constrained in generality, the constraints-on-learning view (for a review, see Johnston, 1981). The underlying tenet is that unless responses and reinforcers are biologically tied together in some way, operant conditioning proceeds only with the greatest difficulty or may even be impossible. Bolles (1979) summarized the gist of the constraints view as pertaining to operant procedures: "apparently, if the required response is too different from the normal consummatory response the animal will not learn it, but will display 'misbehavior' instead" (p. 182).

Earlier researchers, including Thorndike (1911), however, were more impressed by finding that contiguity between response and reinforcement led to conditioning, irrespective of the response's "biological relevance" to the reinforcer, than by finding that the conditioned form of the response might not look quite like the unconditioned form. Thus, Lorge (1936) wrote "any satisfier can strengthen connections [responses] it follows despite lack of relevance or of belongingness to the connection" (p. 128). Konorski (1967) also noted that "transformation of various UR movements [unconditioned responses] into type II [operant] conditioned responses is a routine experimental procedure" (p. 463). Konorski argued that conditioned responses usually preserved their forms indefinitely; this testified to the great "range of flexibility of motor behavior and its remarkable adaptability" (p. 465).

Because the possibility of conditioning of grooming with operant techniques is controversial, more research seems desirable. Some reviews of the constraints literature have suggested that future research take a more comparative and ethological approach and try new experimental procedures (Domjan & Galef, 1983; Fantino & Logan, 1979; Johnston, 1981). As a small step in that direction we attempted to condition grooming with food in vervet monkeys, a species that, to our knowledge, has not been used

before for this line of research. We also made a detailed analysis of grooming forms using modern ethological techniques. As a new experimental procedure, we tried differential reinforcement of subclasses to see if grooming has a "necessary structure" (cf. Baer, 1982), or whether such natural behavior has a structure that can be modified by experimenter-generated contingencies of reinforcement.

Grooming in primates serves hygienic and social functions. Both autogrooming (grooming directed toward the monkey's own fur) and allogrooming (grooming directed toward another monkey's fur) are functional in removing ectoparasites and in cleaning wounds. Allogrooming usually covers body areas, such as the back, that receive little autogrooming (Hutchins & Barash, 1976; Struhsaker, 1967), depends on social context (Rosenblum, Kaufman, & Stynes, 1966), and has been described as a form of tactile communication (Boccia, 1983; Weber, 1973). The ethological literature indicates that grooming behavior in free-ranging monkeys can be influenced by its naturally occurring consequences (e.g., Seyfarth, 1980).

GENERAL METHODS

Subjects

Two female (Ann and Brit) and two male (Ras and Janus) adult vervet monkeys (*Cercopithecus aethiops*) participated in the experiments. The monkeys lived in separate cages in a colony room; they were 23-hr food deprived and received fruit and vitamins after sessions. A 12-hr light-dark cycle (on at 6:00 a.m.) ran continuously. Ann and Brit had no experimental histories. Ras had been used in a circle-ellipse discrimination experiment with food reinforcement about one year earlier. Janus had been used in several experiments on concurrent operant reinforcement schedules with food reinforcement about six years earlier.

Apparatus

In Experiments 1, 2, and 3, the experimental cage measured 70 x 60 x 50 cm.

Mounted on wheels, the cage also transported the subject to and from the experimental room. In the experimental room, the experimenter removed one wall of the cage and attached the cage to an apparatus that had a 3 x 5 x 2-cm food cup mounted 15 cm above the floor. Reinforcement was a one-gram banana-flavored food pellet accompanied by a 2000-Hz tone. The apparatus used in Experiment 4 is described later.

Behavior Recording

To provide a real-time record of each grooming category, we used observation and recording techniques common in ethological studies of naturally occurring behavior (e.g., Rosenblum et al., 1966). The experimenter observed the subjects via a closed-circuit television system and dictated the observed patterns of behavior and delivery of food pellets to a continuously running tape recorder. The experimenter noted the beginning and end of each grooming episode, the part of the body groomed, and whether grooming occurred with hand or foot. During playback of the tape, the experimenter pressed a button for as long as a given grooming episode occurred. The button press activated a pen on an event recorder and enabled a recycling timer to measure the behavior duration (in 0.5-s units). Response probability, the proportion of the session time spent in a given activity, was calculated by dividing the cumulated duration of that behavior by the total session duration.

Behavior Categories

The experimenters recorded and reinforced a class of general grooming or specific behaviors within that class. The general definition of autogrooming used here is derived from previous definitions of Rosenblum et al. (1966) and Goosen and Ribbens (1980). They recorded grooming in vervet monkeys as careful picking through and slow brushing aside of the fur with one or both hands; material picked out, if any, such as hairs and skin flakes, may be transferred into the mouth. In our ex-

periments, grooming typically covered manipulation of the fur on legs, arms, or tail. Occasionally we saw picking of the skin on the anterior side of one hand by the other hand. We also occasionally saw mouth-to-fur contact. The subjects always gazed at the area groomed except during scratching. We did not record grooming when subjects looked away and stopped grooming while still maintaining contact with fur or skin. Scratching was included in the general category of grooming as repeated rhythmical movements (approximately 3 to 5 per s) of hands or feet on fur or skin.

Reliability

The experiments had the following protocol of direct and systematic replication procedures. In Experiment 1, I. I. trained Ann and Brit; K. R. trained Ras, directly replicating the autogrooming data in a monkey with no history of food-reinforced grooming. In Experiment 2, G. R. trained Ann and Brit, systematically replicating maintained operant grooming with a different procedure. In Experiment 3, I. I. trained Janus, but the data were cross-replicated by all investigators. In Experiment 4, I. I. and G. R. alternated in the training of Ann, Brit, and Janus.

EXPERIMENT 1

This experiment explored the possibility of operant control of autogrooming. To establish a baseline of grooming under intermittent food delivery, the subjects first received food pellets independent of their behavior. In an attempt to facilitate grooming, we next presented food pellets contingent on any episode of grooming, and then proceeded to reinforce grooming intermittently. The intermittency of pellet delivery was gradually increased as the time spent grooming increased. As an additional demonstration of operant control with two of the monkeys, we attempted to suppress operant grooming by a schedule that differentially reinforced pauses in grooming. With a third monkey we compared facilita-

tion of grooming with facilitation of another operant, facing the floor of the chamber.

METHOD

Procedure

Ann, Brit, and Ras participated in the experiment. Immediately preceding this experiment, Ann and Brit had been run in a laboratory demonstration of shaping methods. Grooming was not reinforced in this demonstration. To extinguish any previously maintained behavior, the monkeys had three sessions with no pellet delivery immediately prior to the present experiment.

Behaviors recorded. This experiment reinforced the general class of grooming as outlined under general methods. Any instance of grooming qualified for recording and reinforcement.

Baseline. To assess the extent of grooming under exposure to intermittent response-independent food-pellet delivery, a variable-time (VT) 40-s schedule operated for the first three sessions (two sessions for Ras). The interpellet intervals ranged from 3 to 120 s. The experimenter dictated descriptions of grooming to the tape recorder during the last session.

Acquisition. In Session 1, the experimenter delivered a food pellet when almost all grooming episodes occurred. Pellet delivery occurred only while the monkey groomed and never after completion of a grooming burst. For each new grooming form that emerged, a pellet was delivered after 1 or 3 s of continuous grooming. For forms that occurred more and more often, pellets were contingent upon continuous bursts of variable length; the burst duration required for reinforcement was gradually increased during the session, within the range of 3 to 10 s.

In Session 2, pellets were delivered according to a time-based variable-ratio schedule, which we named a variable-duration (VD) schedule, although it is close to what Shettleworth (1975) called a variable cumulative duration (VCD) schedule. Pellet delivery occurred after an accumulated variable duration of grooming. The intermittency of pellet delivery was gradually increased by slowly

incrementing the length of reinforced grooming bursts, which could consist of several bursts of different grooming forms separated by pauses. However, a continuous burst of at least 3 s of the same form always had to precede pellet delivery. The same VD schedule ran throughout Sessions 3 and 4 (and 5 for Ras). To approximately equate the frequency of pellet delivery to that during baseline, the final schedules were VD 20-s for Ann and VD 30-s for Brit and Ras. The accumulated interpellet grooming durations ranged from 3 to 60 s for Ann and from 3 to 80 s for Brit and Ras.

Contingency reversal. For Ann and Brit, food pellets were delivered only when grooming had not occurred for at least 10 s; the schedule changed from VD to VT with the added requirement of a pause in grooming (differential-reinforcement-of-other-behavior schedule, DRO). This condition lasted three sessions for Brit and five sessions for Ann. A VT 20-s schedule ran in Session 1, a VT 30-s in Session 2, and a VT 40-s in Sessions 3 through 5.

Conditioning of other behavior and extinction. For Ras, the experimenter recorded the additional behavior of "face down" when the monkey moved his face to a few cm above the cage floor. After acquisition of grooming, face down was conditioned for five sessions with the same procedure as had been applied to grooming. The final schedule for face down was VD 30-s. During conditioning of face down, no form of grooming was reinforced (extinction). For the next five sessions, no pellets were delivered and both types of behavior were extinguished.

For all subjects, a session stopped when the subject had received approximately 40 food pellets.

RESULTS

The contingencies between grooming and pellet delivery markedly affected grooming. Figure 1 shows the probability of grooming for the last session of each phase for Ann and Brit. Grooming probability increased from about .05 under baseline to more than .50 with contingent food pellets on the VD

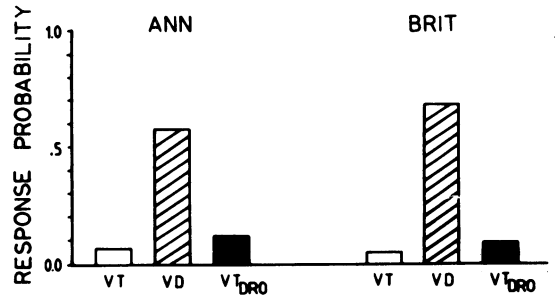


Fig. 1. Probability (proportion of session time) of total grooming (all forms) during the last session of each experimental condition. VT: response-independent reinforcement on a variable-time schedule. VD: response-dependent reinforcement on a variable-duration schedule. VT (DRO): reinforcement dependent on not emitting grooming.

schedule. The contingency reversal decreased grooming probability to approximately .10.

Figure 2 shows cumulative records of grooming. The stepping pen advanced for each second spent grooming. Under the VD schedule, grooming occurred in continuous bursts of varied duration (typically ranging from 2 to 50 s). A short pause in grooming occurred after most pellet deliveries. Overall, the pattern of operant grooming resembles operant behavior maintained by an aperiodic reinforcement schedule. Under contingency reversal, grooming occurred irregularly and much less frequently.

Ras' grooming activities were recorded in more detail. Figure 3 shows the probabilities of hand, arm, and foot grooming and of face down for each session. Total grooming probability increased gradually to about .50 towards the end of acquisition, the increase consisting primarily of grooming the fur on one arm. The face-down behavior remained infrequent throughout acquisition of grooming. But when the experimenter began to reinforce face-down behavior and stopped reinforcing grooming, face down quickly increased almost to the same level as grooming had been in the first acquisition phase. Total grooming simultaneously decreased. However, hand and arm grooming had not quite extinguished and may have competed with face down to prevent the same terminal level as conditioned grooming. When the experi-

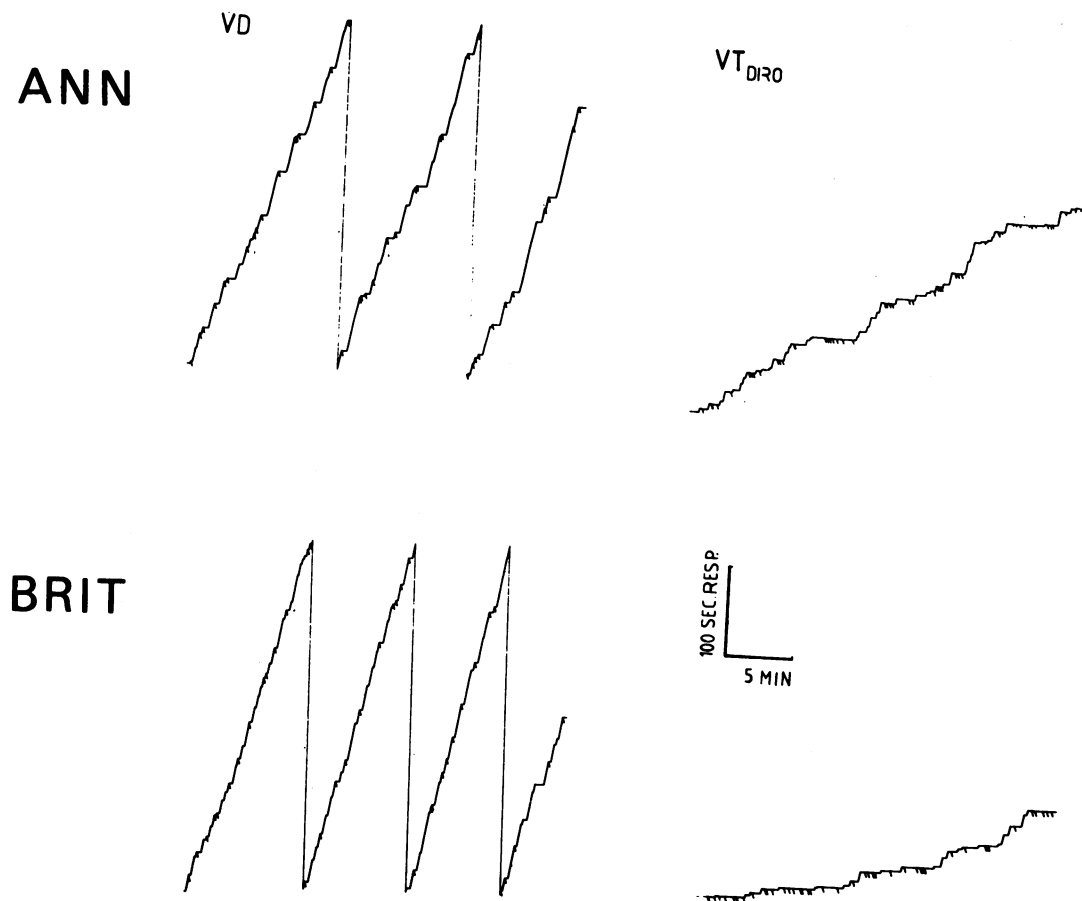


Fig. 2. Cumulative records of total grooming from the last sessions of VD and VT (DRO). The stepping pen advanced once per second spent in any form of grooming. Hatchmarks indicate pellet deliveries.

menter no longer presented food pellets, the probability of face down decreased. Total grooming increased, but did not reach the same level as with reinforcement of grooming.

Figure 4 shows cumulative records of grooming and face-down behavior for each session for Ras. Grooming increased from low frequency and short bursts to high frequency and long bursts from baseline to reinforcement of grooming. By Session 4, grooming occurred in extended and frequent bursts ranging from 1.0 to 71.0 s; under baseline, bursts ranged from 1.0 to 7.5 s. With reinforcement of face down and extinction of grooming (stepping pen and event pen switched in Figure 4), face down gradually increased and grooming gradually

decreased in the first session. From Session 3, the pattern of face down resembled the previous pattern of reinforced grooming; however, short bursts of grooming interrupted face down, in particular after reinforcement (see Session 5).

Under extinction of both types of behavior, the frequency and burst durations of face down decreased and the pattern became erratic with frequent interruptions by grooming bursts, which increased in frequency and duration. By Session 5, the frequency and bursts of both had decreased compared to conditioning sessions, but were higher than during baseline.

DISCUSSION

Grooming bursts increased both in fre-

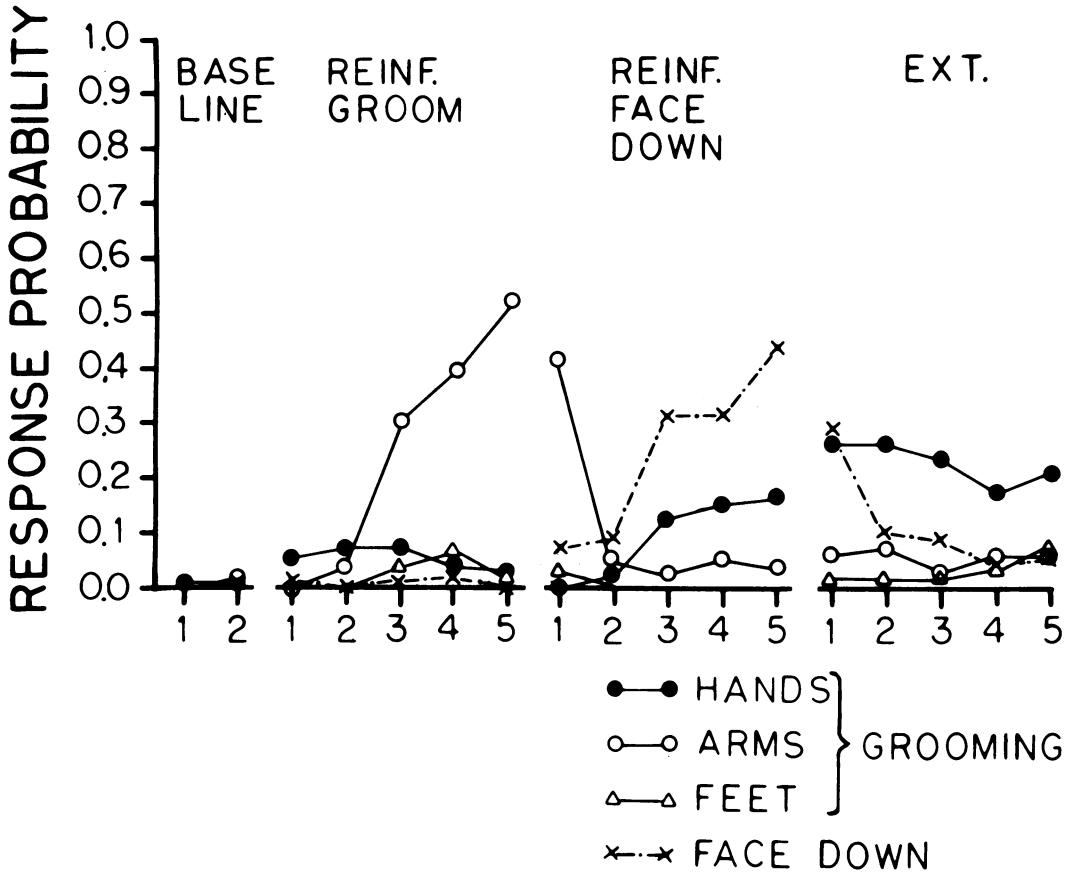


Fig. 3. Probability of hand, arm, and feet grooming and of face-down behavior for each session in each phase of the experiment.

quency and duration when food was contingently delivered. The schedule of a variable-duration response requirement for pellet delivery led to continuous grooming bursts that far exceeded those obtained under baseline (a few seconds during baseline and up to 71 s during acquisition). When food delivery was contingent on pauses, and during extinction, grooming bursts decreased in frequency and duration. The general class of autogrooming in the vervet monkey was therefore easily amenable to operant control by means of food reinforcement.

Grooming occurred under acquisition with no fragmentary or unnatural-looking episodes. To us, therefore, operant grooming looked like baseline grooming.

The monkeys always oriented their gaze to the skin area they groomed (except for scratching). The only clear difference between baseline and operant grooming was the increase in burst frequency and duration.

Because baseline, acquisition, and contingency reversal for Ann and Brit eventually led to similar pellet rates but very different grooming frequencies and durations, the results cannot be explained by some form of induction from or elicitation by intermittent pellet presentation.

When the contingency shifted to a different response for Ras, that response increased and grooming decreased. The two behavior forms reached roughly comparable levels during their respective final

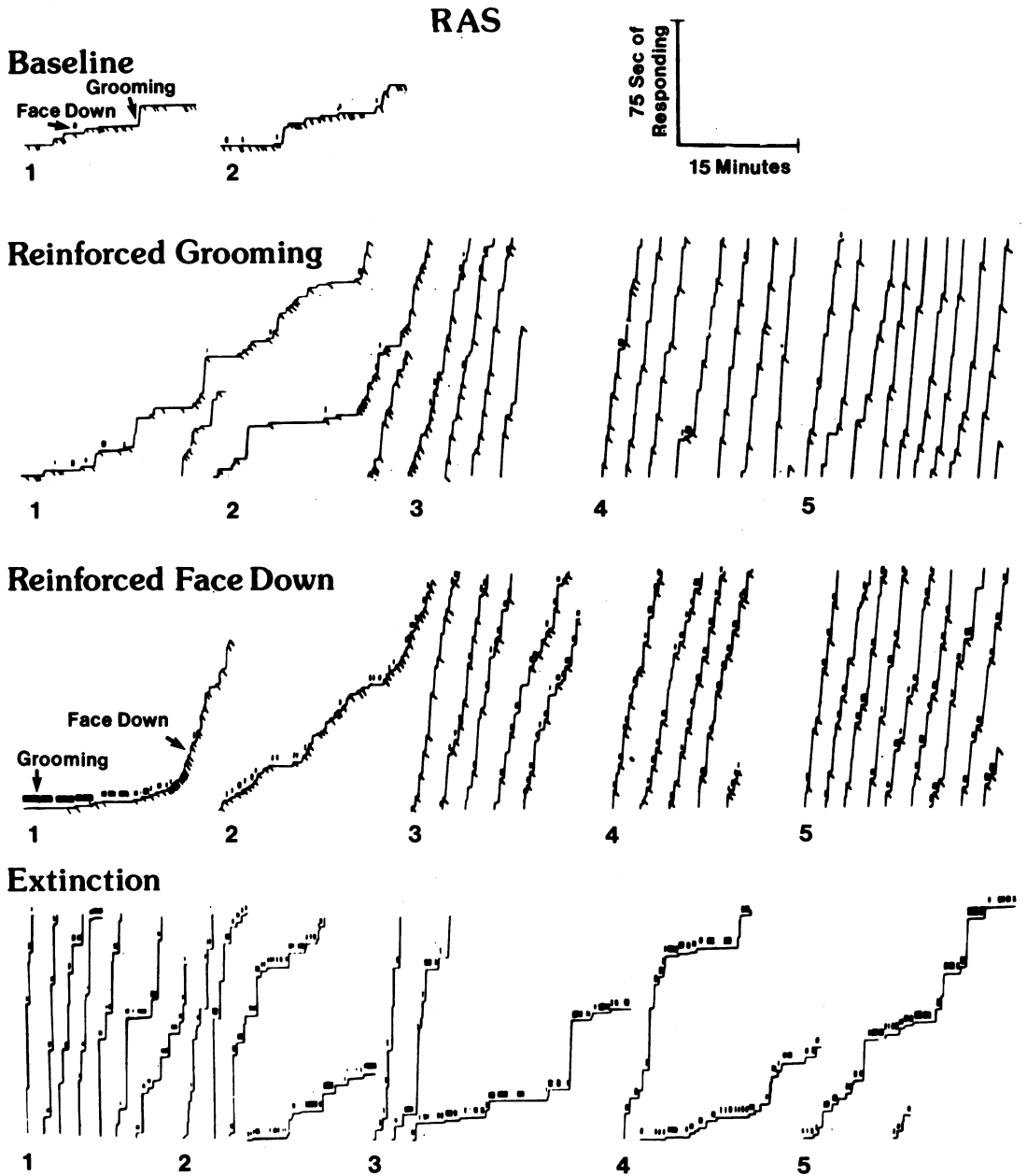


Fig. 4. *Baseline and reinforced grooming*: Cumulative records of total grooming for each session of baseline and acquisition of grooming; the event pen shows face down with the active segments transposed to just above the track on the cumulative records for easy comparison. *Reinforced face down and extinction*: Cumulative records of face down for each session of acquisition of face down and extinction; the event pen shows total grooming. For all records, the stepping pen advanced once per half second spent responding, and the event pen displaced once per half second spent responding. Hatchmarks on the cumulative records indicate pellet deliveries.

conditioning sessions. The increased grooming under extinction of both behaviors resembles the phenomenon of resurgence (Epstein, 1983; Epstein & Skinner, 1980; Lindblom & Jenkins, 1981; Rawson, Leiten-

berg, Mulick, & Lefebvre, 1977). When an operant is extinguished along with conditioning of a second operant on a spatially separate operandum, then the first operant, still under extinction, reappears temporarily

when the second operant is extinguished.

In addition, the patterns of moment-to-moment reciprocal interaction between face down and grooming resemble interacting patterns between operants in concurrent reinforcement schedules and between operants and collateral responses in simple and multiple schedules (cf. Henton & Iversen, 1978).

EXPERIMENT 2

Degree of variability among response forms within an operant class generally depends upon limits set by the class definition (Skinner, 1953). With wide limits, variability in form may be large; with narrow limits, variability is small. Response-class differentiation consists of dividing the class by differentially reinforcing a particular subclass. One response form then becomes frequent and the unreinforced forms infrequent. Further differentiation by extinguishing part of a previously reinforced response class essentially decreases variability by narrowing the class definition.

A further demonstration of operant control of grooming in vervet monkeys would be differentiation of grooming forms. Experiment 2 attempted to break down the wide class of grooming from Experiment 1 by reinforcing only a single grooming form within that class. To demonstrate reliability and promptness of response differentiation, we reinforced a new grooming form during each successive session.

METHOD

Procedure

Ann and Brit participated in the experiment, 4 months after Experiment 1 and 1 week after Experiment 4. For each of four successive daily sessions, the experimenter reinforced a different grooming form: picking and searching the fur on either legs, tail, hands, or feet.

The experimenter presented food pellets contingent on an accumulated fixed duration of 12 s of the specified grooming form, a

fixed-duration (FD) schedule. Reinforced grooming could consist of several short bursts adding up to 12 s or of one 12-s burst; but at least 3 s of uninterrupted grooming always had to precede pellet delivery. For each session, the experimenter reinforced only one grooming form. The other forms were recorded but not reinforced. To extinguish the previously conditioned grooming form(s), each session (except for the first) began with 15 min of no reinforcement. For Ann, the operant schedule in Session 1 was VD 20-s instead of FD 12-s. Sessions terminated after delivery of about 40 food pellets.

RESULTS

Figure 5 shows grooming probabilities for the last 15 min of each session. Shaded bars

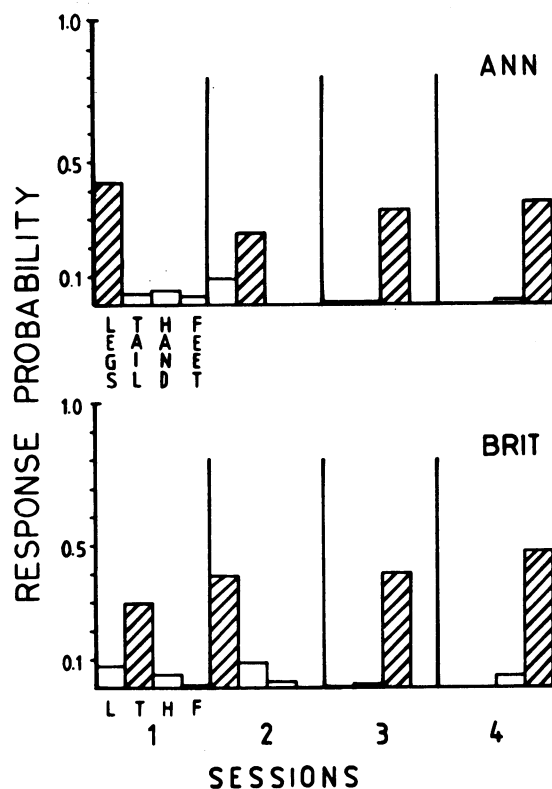


Fig. 5. Probability of each of four different grooming forms. In each session only one grooming form received reinforcement on a fixed-duration schedule (shaded bars). The four grooming forms were leg, tail, feet, and hand grooming. Data are from the last 15 min of each session. Sessions occurred in daily succession.

indicate the reinforced grooming form. In Session 1, the probability of reinforced grooming increased above the probabilities of nonreinforced grooming. In Session 2, reinforcement was contingent on a new form, and that form came to dominate. However, the form reinforced in Session 1 carried over to Session 2, with the highest probability of nonreinforced grooming occurring for the form that had been reinforced in Session 1. Very little nonreinforced grooming occurred by the end of the last two sessions.

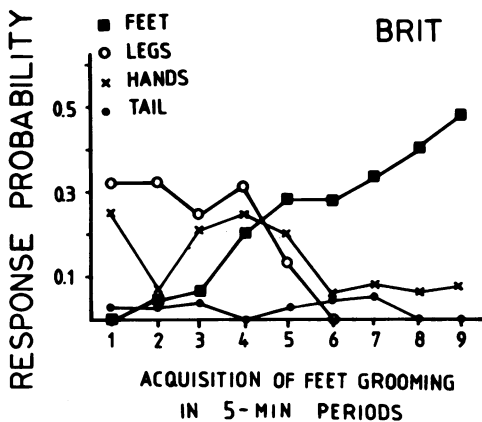


Fig. 6. Probability of each of four grooming forms in 5-min blocks for Brit for the session with reinforcement of feet grooming. Leg grooming had been reinforced in the session the day before, hand grooming 2 days before, and tail grooming 3 days before.

An example of the inverse relation between previously and currently reinforced grooming appears for Brit in Figure 6. Data are for each 5-min period of Session 4 with reinforcement of feet grooming. Hand and leg grooming dominated for the first 20 min (hand grooming was reinforced in Session 3, leg grooming in Session 2, and tail grooming in Session 1). As the new reinforced form increased, the previously reinforced forms gradually decreased. Only hand grooming, reinforced in the preceding session, persisted toward the end of the session.

For each session under the FD schedule, reinforced grooming gradually developed into a pattern characteristic of periodic reinforcement schedules, with steady emission before reinforcement and a pause after rein-

forcement. Figure 7 displays segments of event records from Session 3 for Brit. Leg grooming dominated the beginning of the session (Segment A). Then, hand grooming began to occur more frequently shortly after the first pellets for hand grooming (Segment B). Finally, hand grooming dominated in a pattern typical of behavior reinforced under periodic schedules (Segment C).

DISCUSSION

Contingent reinforcement again increased the probability of grooming. In particular, a given grooming form could easily be made dominant toward the end of a daily session by reinforcing only that form.

The literature has usually specified response differentiation with respect to, for example, force exerted on a lever (e.g., Notterman & Mintz, 1965) or spatial response location on a strip of keys (e.g., Eckerman, Hienz, Stern, & Kowlowitz, 1980). The present experiment adds response location on the subject's body as a feasible criterion for response-class definition. The experimenter can thus, by means of contingency management, suppress variability in grooming forms and explicitly determine which body site the subject grooms.

The experiment also shows that the change from aperiodic (Experiment 1) to periodic reinforcement quickly altered the pattern from relatively steady emission with variable response bursts under VD reinforcement to a "break and run" pattern under FD reinforcement. The pattern of operant grooming therefore adjusted to the pattern of reinforcement, just as operant behavior does in general (Ferster & Skinner, 1957).

EXPERIMENT 3

In Experiment 3, we differentially reinforced scratching as a separate class of grooming. Previous results indicate that scratching (in rodents) can be particularly difficult to condition with food (e.g., Shettleworth, 1975). We tried a technique with pellets contingent on variability of scratch-

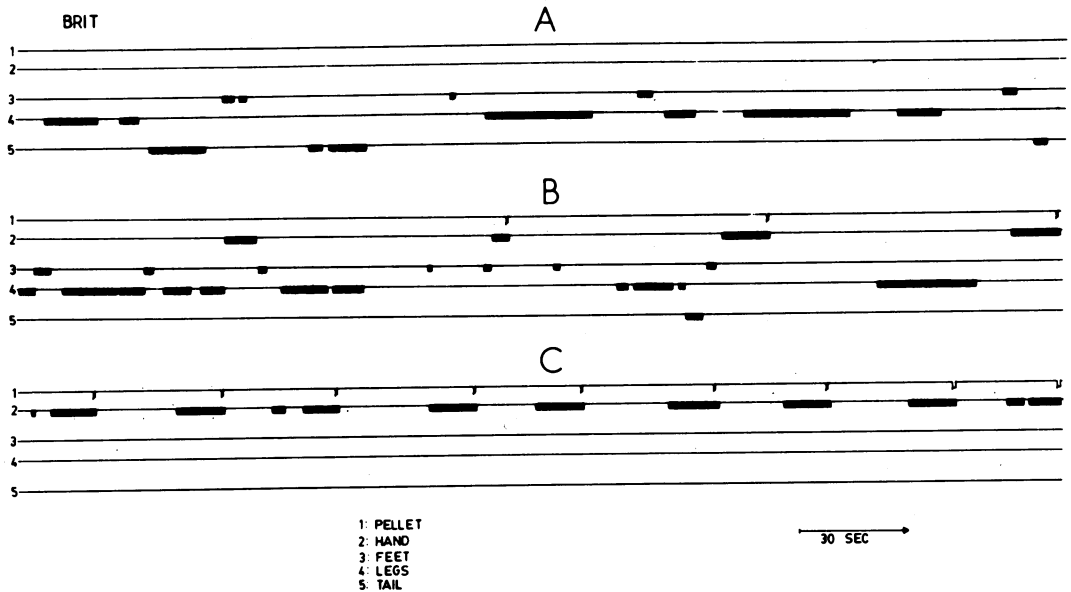


Fig. 7. Segments of event records showing pellet delivery, hand, feet, leg, and tail grooming from the beginning of the session (A), after grooming had been reinforced three times (B), and the last minutes of the session (C). Data are from Session 3 for Brit.

ing; the same scratching form could not be reinforced consecutively.

METHOD

Procedure

Janus participated in the experiment. About 3 months earlier, Janus participated in Experiment 4 and then in a two-session shaping exercise and a preliminary experiment.

Preliminary experiment. For two sessions, one experimenter attempted to reinforce each episode of any scratching form. Scratching quickly concentrated on a particular location (rapid right-hand movements on the fur of the right thigh). Then a second experimenter took over and reinforced scratching intermittently. After two sessions, however, the behavior had changed to scratching "in the air" a few cm above the fur on the right thigh. For the next two sessions, we delivered food pellets contingent upon 10-s periods without any scratching. This resulted in virtual absence of any scratching form. Unfortunately, we did not record data in this preliminary experiment.

Primary experiment. The experimenter had

three sessions. The experimenter explicitly reinforced variety in scratching form. The same form was never reinforced on two successive occasions. At least one burst of a different scratching form had to intervene and be reinforced before a given form was reinforced again. For example, if the experimenter reinforced scratching on the left side with the left hand (one scratching form), then some other scratching form, such as scratching the back with the left foot, had to be reinforced before the experimenter again reinforced scratching on the left side with the left hand. The experimenter reinforced only scratching bursts that lasted at least 1 s (judged subjectively).

In Session 1, the experimenter reinforced each scratching burst that satisfied the above criteria. During Session 2, the experimenter introduced intermittency in pellet delivery by reinforcing, on average, every third scratching burst in the first half of the session and, on average, every fifth burst in the second half. The terminal schedule was a variable-ratio (VR) 5 with the added requirement that the same scratching form was not reinforced successively. Session 3 had two parts. First, the experimenter reinforced

scratching on the VR-5 schedule until 34 food pellets had been delivered. Second, to extinguish scratching, the experimenter did not deliver any pellets for the remainder of the session.

In Session 1, the data recording technique used in the previous experiments proved unpracticable; too many different scratching forms occurred in too rapid a succession for

the experimenter to be able to keep up with both dictation and control of pellet delivery. Therefore, in Sessions 2 and 3 we used a videorecorder to retrieve the behavioral record. Data presented derive from playback of the videotape from Session 3.

RESULTS

Figure 8 presents a transcript of the entire

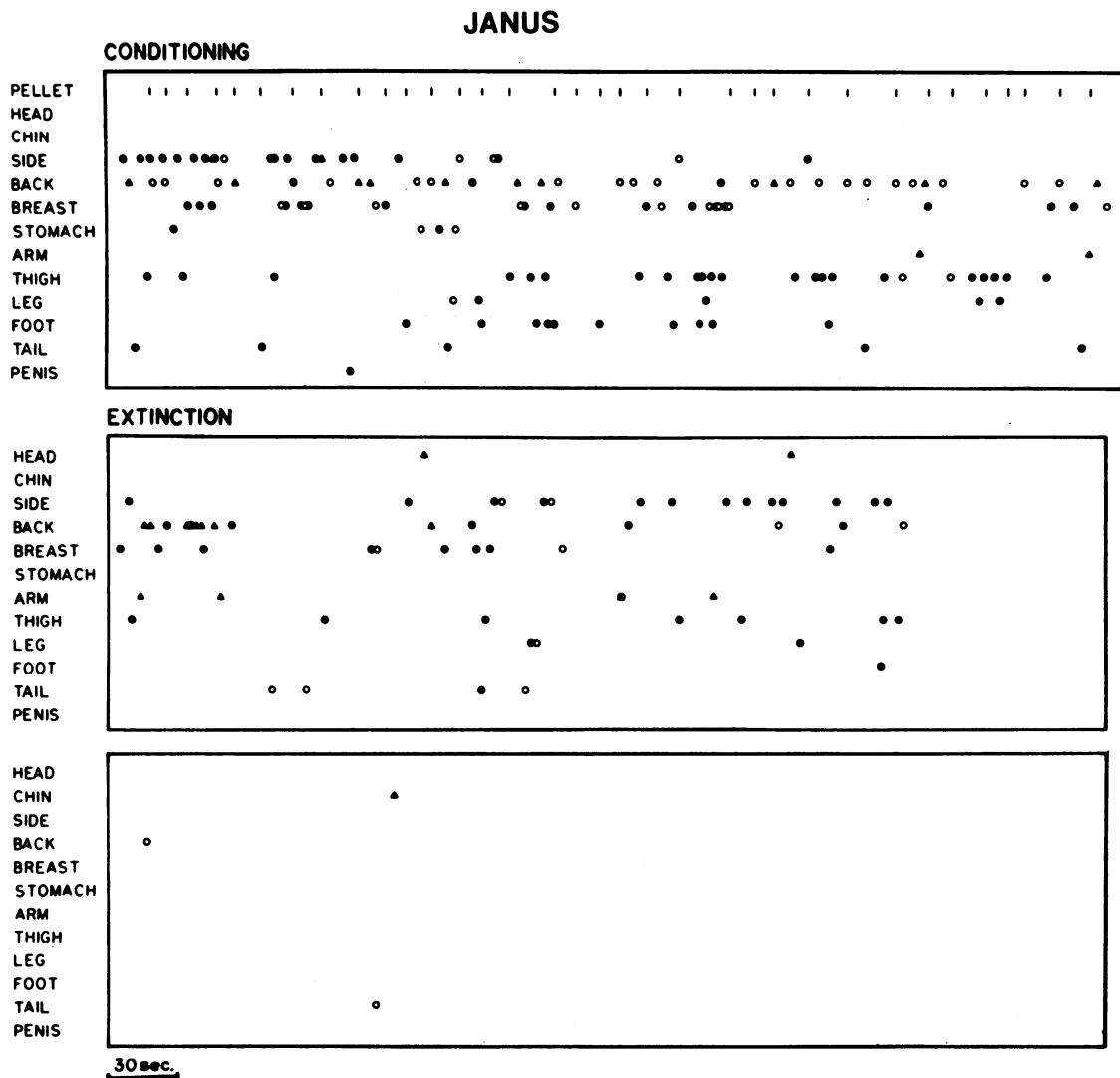


Fig. 8. Behavioral record showing each scratching burst and all pellet deliveries for the entire length of Session 3. Under conditioning (the first 7 min of the session), reinforcement was contingent on scratching. A small VR schedule reinforced scratching but the same scratching form could not be reinforced successively. With no interruption in the session, extinction followed for approximately 14 min with no pellet delivery. The scratching forms are shown with respect to location on the body. Symbols indicate the hand or foot involved in the scratching burst. Filled circles: right hand; unfilled circles: left hand. Filled triangles: right foot; unfilled triangles: left foot. Marks in the upper row indicate pellet deliveries.

behavioral record of all scratching episodes for Session 3. Each symbol refers to one scratching burst. Filled and unfilled circles refer to scratching with the right and left hand, respectively. Filled and unfilled triangles refer to scratching with the right and left foot, respectively. The body locations of scratching appear at the left. The first symbol thus represents scratching the side with the right hand, and the second symbol represents scratching the back with the left foot. Pellets are indicated by marks in the upper row.

The procedure led to frequent scratching and considerable variety in scratching form. During conditioning, 133 scratching bursts occurred with an overall rate of 19 scratches per min. Considering each combination of area scratched and hand or foot used in scratching as a separate scratching form, 18 different forms occurred. About half of all scratching bursts involved the right hand. During extinction (last two blocks in Figure 8), scratching continued for about 1 min, then decreased for a few minutes only to reappear at a frequency almost as high as during conditioning. After about 5 min of extinction, scratching stopped quite abruptly and occurred only three times during the next 9 min. The variety in scratching forms seen during conditioning remained during extinction; some new forms emerged, but others dropped out. The same scratching forms dominated during conditioning and extinction. During extinction, Janus emitted 64 scratching bursts in 19 different forms.

Scratching appeared natural both during conditioning and extinction, with the hand or foot contacting the scratched location. We did occasionally see a scratching burst too brief to satisfy the 1-s criterion.

DISCUSSION

This experiment provides a procedure to condition scratching with food in vervets. Quite a variety of scratching forms occurred during conditioning sessions. The conditioned scratching behavior decreased in frequency under extinction and was therefore under control of the food-pellet contingency.

As a comparison, in Experiment 4 (conducted before Experiment 3) with response-independent pellet delivery, Janus scratched only once or twice each session. We did not analyze the scratching forms in Experiment 4, but we had never before seen some of the forms that appeared in Experiment 3, like breast, ear, and penis scratching. This procedure of reinforcing variety in behavioral forms may have similarities with procedures that reinforce novelty in behavior (Goetz & Baer, 1973; Pryor, Haag, & O'Rielly, 1969).

Operant conditioning of scratching in cats, rodents, and birds has been attempted in the past with varied degrees of success. Our main purpose was to show that scratching could be conditioned in vervets, not to find critical procedural aspects responsible for the results. The particular method chosen, of conditioning variety in scratching by not allowing the same scratching form to be successively reinforced, may have been important in preventing the appearance of unnatural patterns or topographies of scratching.

The preliminary experiment allowed for repeated reinforcement of a single scratching form, and unnatural scratching did develop. Both Hogan (1964) and Konorski (1967) similarly reported that conditioned scratching may change into an unnatural form if allowed to do so. The rule seems to be that if the experimenter reinforces such scratching forms they persist, but if the experimenter stops doing so, then they disappear (Konorski, 1967).

EXPERIMENT 4

Previously reported difficulties in operant conditioning of grooming in other species have suggested that certain types of behavior are biologically constrained or counter-prepared for operant conditioning. One underlying theory is that a response must be compatible with "anticipation" of the reinforcer for that response to become an operant (Mackintosh, 1974). This view has been tested in experiments with classical conditioning procedures, in which a stimulus

precedes response-independent reinforcement. Grooming typically does not increase during such stimuli (Shettleworth, 1978). In our experiments operant grooming was easily conditioned with food reinforcement. What, then, would happen to grooming during a stimulus that preceded response-independent food? According to the anticipation view, if operant grooming is difficult to establish, then such a stimulus should not facilitate grooming. Conversely, if operant grooming is easy to establish with food reinforcement, then grooming should increase during a prefood stimulus.

Experiment 4 presented a brief visual stimulus preceding delivery of response-independent reinforcement. The subjects were Ann, Brit, and Janus. To assess whether previous operant conditioning of grooming had any effect on grooming during the prefood stimulus, we presented Ann and Brit with this procedure after Experiment 1; Janus, on the other hand, had this procedure before his exposure to operant conditioning of grooming.

METHOD

Apparatus

The experimental chamber measured 80 x 45 x 60 cm with side walls and end walls made of transparent Plexiglas. One end wall had a stimulus source centered 25 cm above the grid floor. The stimulus was a 1.5-cm diameter green surface that could be lit from behind by a 5-W light blinking with a period of 0.6 s. An 8-cm diameter metal disc surrounded the stimulus source with the stimulus located at the center. Using a body-capacitance detector, we recorded contact with either the metal disc or the stimulus. A 6 x 2-cm metal food cup was centered on the opposite wall 25 cm above the grid floor.

Procedure

Each subject had five 40-min sessions. The green stimulus light blinked for 15 s preceding response-independent pellet delivery. A VT 2-min schedule, with a range from 30 s to 6 min, determined the interstimulus intervals.

RESULTS

For Ann, the proportion of the interstimulus period spent grooming was .09 and the proportion for the stimulus period was .04. For Brit these proportions were .04 and .01. For Janus they were .02 and .01. The proportions are based on the data from the last two sessions. So, for all subjects grooming did not increase, or perhaps decreased slightly, during stimulus compared to interstimulus periods. Ann and Brit groomed more than Janus, presumably because they had a previous history of operant grooming.

If a subject happened to be grooming at stimulus onset, grooming stopped almost immediately, except when the subject faced away from the stimulus. Stimulus onset typically controlled looking at or directly contacting the stimulus with either hands, mouth, or nose. As the stimulus period progressed, these behavior patterns alternated with looking back to the food cup. Toward the end of the stimulus, the subject typically moved away from the stimulus toward the food cup. For Ann, the proportion of the interstimulus interval spent in contact with the stimulus source was .01 and the proportion for the stimulus period was .11. For Brit these proportions were .005 and .02. For Janus they were .005 and .26. The prefood stimulus thus generated a large increase in stimulus-contacting behavior patterns.

Mouth contacts with the stimulus could be with open or closed mouth. Hand contacts consisted of manipulating the stimulus with the fingers or occasionally covering the stimulus with a palm. During interstimulus periods, the subjects occasionally glanced at the dark stimulus source or the food cup.

DISCUSSION

In Experiments 1, 2, or 3, all monkeys increased grooming when we presented reinforcement contingent on grooming, yet no monkey's grooming increased during the prefood stimulus in Experiment 4. So absence of an increase, or even a decrease, in grooming during a prefood stimulus does not imply that grooming is difficult to condi-

tion as an operant. The ease of operant conditioning of a response, therefore, cannot necessarily be predicted from the predominance of that response during classical conditioning using the same reinforcer. Likewise, Shettleworth (1978) found no increase in scrabbling in golden hamsters during a prefood stimulus; however, scrabbling could easily become an operant with food as the reinforcement. Also, Williams and Teitelbaum (1956) conditioned licking in rats with food reinforcement, yet Stone, Lyon, and Anger (1978) did not find an increase in rats' licking during a prefood stimulus. Similarly, a prefood stimulus does not increase monkeys' lever pressing, yet lever pressing certainly can be conditioned as an operant with food reinforcement (cf. Henton & Iversen, 1978).

All subjects in this experiment contacted the prefood stimulus with a hand or with the mouth, indicating that the classical conditioning procedure controlled their behavior. Previous experiments with monkeys similarly found that prefood stimuli augment stimulus-approach behavior (Henton & Iversen, 1978; Likely, 1974; Sidman & Fletcher, 1968).

GENERAL DISCUSSION

Food reinforces autogrooming in vervet monkeys. Grooming appeared natural in all experiments and did not deviate from the classification used. Unnatural-looking grooming, therefore, is not a necessary outcome of experiments that attempt operant conditioning of grooming, at least not with vervets and food reinforcement. Some previous experimenters saw the need for using artificial irritants to augment grooming or scratching in combination with the conditioning procedure. In our experiments, grooming easily became conditioned without the use of irritants and quickly came under control by arbitrary stimuli provided by the experimental chamber; in all experiments with food pellets contingent on grooming the subjects would usually begin grooming as soon as they arrived in the experimental room. The results support the view that operant

conditioning is possible when the selected response is not functionally relevant for the reinforcer. Grooming in monkeys can be conditioned as an operant with food reinforcement even though that behavior is not a natural way of obtaining food.

The present results contrast with some past research showing that operant grooming may drift into an unnatural-looking form, sham grooming. Emergence of such "misbehavior" has at times directed investigative efforts from experimental to theoretical analyses, with the emerging misbehavior used as an indicant of some underlying explanatory state or constraint.

More recent reviews of the biological-constraints literature indicate that known principles of behavior can explain at least part of the findings hitherto used to support the constraints-on-learning view (cf. Domjan, 1983). Along these lines, we take the opportunity to discuss how reinforcement principles could explain emerging sham grooming. Sham grooming clearly is not the unconditioned grooming form. Yet, an experimenter can apparently shape or generate this behavior by reinforcing very short bursts of regular grooming (e.g., Shettleworth, 1975). The customary operants, lever pressing and key pecking, similarly are shaped by reinforcing other behavior of a related form. But here the process of shaping works in the opposite direction, so to speak; first the experimenter reinforces sham lever pressing (or key pecking) in the air closer and closer to the lever (or key), and eventually the subject hits the lever (or key). Sham grooming is similar to lever pressing in that both activities are nearly nonexistent before conditioning, and both are unrelated to any reinforcer. For this reason, the success of operant conditioning of lever pressing has been something of an embarrassment to the constraints-on-learning view and has led to the argument that rats in fact do not press but instead bite or chew the lever, as if the consummatory behavior has carried over to the operant. In our experiments, operant grooming showed no resemblance to food-related behavior. Rather, our subjects would

on occasion interrupt ongoing grooming to push food from a chin pouch into the mouth cavity. Kelly (1974) similarly reported that rhesus monkeys interrupted food-reinforced lever pressing when engaging in feeding-related behavior. Operant behavior patterns resembling reinforcer retrieval and consumption no doubt occur in some experiments (e.g., Hull, 1977; Spetch, Wilkie, & Skelton, 1981), but the critical variables that determine when such behaviors fuse with or compete with the operant need further analysis.

The appearance of natural or unnatural operant grooming directs attention to how behavior is classified. Catania (1973) drew the distinction between the reinforced response class (the defined operant) and the response class that results from such reinforcement (the functional operant). Such classes may or may not be identical, depending upon particular conditioning procedures. With positive reinforcement, behavior within the defined operant increases in frequency, but other behavior may also increase. Usually, behavior of a form close to the defined operant also will increase after reinforcement (cf. Notterman & Mintz, 1965), and this increase has been referred to as response induction or generalization.

Skinner's (1953) analysis of contingencies of reinforcement addresses this issue. Very few behavior forms are discrete, like sneezing and yawning. Instead, each identified behavior occurs in continuity with other behavior. In the case of lever pressing in rats, movement toward the lever, lifting the paw, and depressing the paw with insufficient force all occur in rapid succession prior to a recorded lever press. Such other behavior forms in close spatial and topographical continuity with the reinforced form also may become conditioned. A well known example is the pigeon's often emitted but always unreinforced off-key pecking, which may occur concurrently with reinforced on-key pecking (Bachrach, 1966; Dunham, Mariner, & Adams, 1969). Similarly, rats' unreinforced nose-key responding can be generated and maintained when proximity

to but *not* contact with the key is the reinforced response class (Iversen, 1982). Lucas (1975) showed that pigeons' unreinforced key pecks during prefood stimuli could not be maintained when pre-key pecks close to the response key were excluded from adventitious reinforcement.

In the case of grooming, continuity with other behavior does exist. During movement of a hand toward the fur or skin and movement to and from the skin between strokes in scratching, the hand literally is in the air. If the experimenter happens to deliver reinforcement during these precursors to contact with the fur, then the precursors may be conditioned and unnatural forms of conditioned grooming may be the result. In this respect, the effect of conditioning of grooming certainly resembles the effect of conditioning of other behavior. By explicitly reinforcing borderline cases, the entire distribution of behavior may shift, even to the extent that the original forms disappear (Eckerman *et al.*, 1980). A frequent laboratory observation with rats is that the form of an operant, say lever pressing, may in fact change during an experiment from the original experimenter-shaped more or less "clean" paw movement into pressing the lever, for example, with the side of the body. Similarly, in pigeons, activating a key may drift from pecking to responding with a foot (Pliskoff & Gollub, 1974). The possible emergence of response forms that differ from the form the experimenter originally conditioned is therefore not unique to conditioning of natural behavior patterns.

The literature does not always specify whether sham grooming was part of the defined (reinforced) operant. If allowed within that class, such behavior occasionally will be reinforced and therefore maintained. Our 3- or 1-s minimum requirement for a grooming burst before reinforcement prevented borderline grooming forms from being contiguous with reinforcement and sham grooming did not develop. In Experiment 3, we did see sham scratching when we did not use any burst criterion and thus permitted very short bursts to be reinforced. Many ex-

perimenters attempting to condition grooming have used very brief durations as criteria for reinforcement. Such reinforced bursts are frequently as short as the observer's latency. With such short response bursts before reinforcement, the next-to-last response may also become conditioned (Iversen, 1984) and unnatural-looking forms may emerge. Konorski (1967) and Morgan and Nicholas (1979) reported that sham grooming disappeared when the defined operant was changed to eliminate borderline grooming forms from contiguity with reinforcement by increasing the length of the reinforced grooming burst. In applied behavior analysis, Kazdin (1977) similarly reported that operant conditioning of a target response was less efficient when an inappropriate response preceded a reinforced appropriate response; an increase in the length of the last burst of the appropriate response improved the efficacy of the operant conditioning procedure.

The relative ease of establishing operant grooming in monkeys compared with the reported difficulties in other species might suggest that constraints on learning do not operate equally strongly in all species. Given this view, constraints on learning would then become species specific, and the principles of constraint would be limited in applicability to only some species and situations. Given the current data base, species specificity cannot be ruled out.

The multitude of experimenter-controlled alterations in autogrooming points to the importance of manipulating contingencies of reinforcement in the study of behavior patterns that are said to be constrained for learning. Charlton (1983) also suggested that reasons for differential conditionability of behavior might be sought in differential contingencies of reinforcement.

The use of ethological recording techniques in our experiments allowed for the detailed recording and control of grooming form and novelty. In addition, the procedures of response differentiation demonstrated that the structure of vervet grooming is very flexible. Indeed, the frequency, dura-

tion, pattern, form, and novelty of autogrooming were direct functions of operant response-reinforcer contingency manipulations rather than having been constrained by biological response-reinforcer relevance or Pavlovian compatibility. The present contingency management does suggest that the acquisition, differentiation, and extinction of vervet autogrooming is wholly consistent with operant schedule analysis.

REFERENCES

- Annable, A., & Wearden, J. H. (1979). Grooming movements as operants in the rat. *Journal of the Experimental Analysis of Behavior*, *32*, 297-304.
- Bachrach, A. J. (1966). A simple method of obtaining a scatter distribution of off-key pigeon pecking. *Journal of the Experimental Analysis of Behavior*, *9*, 152.
- Baer, D. M. (1982). The imposition of structure on behavior and the demolition of behavioral structures. In D. J. Bernstein (Ed.), *Nebraska Symposium on Motivation: Vol 29. Response structure and organization* (pp. 217-254). Lincoln: University of Nebraska Press.
- Boccia, M. L. (1983). A functional analysis of social grooming patterns through direct comparison with self-grooming in rhesus monkeys. *International Journal of Primatology*, *4*, 399-418.
- Bolles, R. C. (1979). *Learning theory* (2nd ed.). New York: Holt, Rinehart, & Winston.
- Breland, K., & Breland, M. (1961). The misbehavior of organisms. *American Psychologist*, *16*, 681-684.
- Catania, A. C. (1973). The concept of the operant in the analysis of behavior. *Behaviorism*, *1*(2), 103-116.
- Charlton, S. G. (1983). Differential conditionability: Reinforcing grooming in golden hamsters. *Animal Learning & Behavior*, *11*, 27-34.
- Domjan, M. (1983). Biological constraints on instrumental and classical conditioning: Implications for general process theory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 17, pp. 215-277). New York: Academic Press.
- Domjan, M., & Galef, B. G., Jr. (1983). Biological constraints on instrumental and classical conditioning: Retrospect and prospect. *Animal Learning & Behavior*, *11*, 151-161.
- Dunham, P. J., Mariner, A., & Adams, H. (1969). Enhancement of off-key pecking by on-key punishment. *Journal of the Experimental Analysis of Behavior*, *12*, 789-797.
- Eckerman, D. A., Hienz, R. D., Stern, S., & Kowlowitz, V. (1980). Shaping the location of a pigeon's peck: Effect of rate and size of shaping steps. *Journal of the Experimental Analysis of Behavior*, *33*, 299-310.
- Epstein, R. (1983). Resurgence of previously reinforced behavior during extinction. *Behavior Analysis Letters*, *3*, 391-397.
- Epstein, R., & Skinner, B. F. (1980). Resurgence of responding after cessation of response-independent reinforcement. *Proceedings of the National Academy of Sciences of the United States of America*, *77*, 6251-6253.

- Fantino, E., & Logan, C. A. (1979). *The experimental analysis of behavior: A biological perspective*. San Francisco: Freeman.
- Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement*. New York: Appleton-Century-Crofts.
- Goetz, E. M., & Baer, D. M. (1973). Social control of form diversity and the emergence of new forms in children's blockbuilding. *Journal of Applied Behavior Analysis*, *6*, 209-217.
- Goosen, C., & Ribbens, L. G. (1980). Autoaggression and tactile communication in pairs of adult stump-tailed macaques. *Behaviour*, *73*, 155-174.
- Henton, W. W., & Iversen, I. H. (1978). *Classical conditioning and operant conditioning: A response pattern analysis*. New York: Springer-Verlag.
- Hinde, R. A., & Stevenson-Hinde, J. (Eds.). (1973). *Constraints on learning: Limitations and predispositions*. New York: Academic Press.
- Hogan, J. A. (1964). Operant control of preening in pigeons. *Journal of the Experimental Analysis of Behavior*, *7*, 351-354.
- Hull, J. H. (1977). Instrumental response topographies of rats. *Animal Learning & Behavior*, *5*, 207-212.
- Hutchins, M., & Barash, D. P. (1976). Grooming in primates: Implications for its utilitarian function. *Primates*, *17*, 145-150.
- Iversen, I. H. (1982, March). *Contiguity and response generalization*. Paper presented at the Easter conference of the Experimental Analysis of Behaviour Group, University of Cambridge, England.
- Iversen, I. H. (1984, May). *The power of temporal contiguity*. Symposium paper presented at the tenth annual convention of the Association for Behavior Analysis, Nashville, TN.
- Johnston, T. D. (1981). Contrasting approaches to a theory of learning. *The Behavioral and Brain Sciences*, *4*, 125-173. (Includes commentary)
- Kazdin, A. E. (1977). The influence of behavior preceding a reinforced response on behavior change in the classroom. *Journal of Applied Behavior Analysis*, *10*, 299-310.
- Kelly, D. D. (1974). Two unlike patterns of random-ratio responding associated with different eating habits in rhesus monkeys. *Journal of the Experimental Analysis of Behavior*, *22*, 169-177.
- Konorski, J. (1967). *Integrative activity of the brain*. Chicago: University of Chicago Press.
- Likely, D. G. (1974). Autoshaping in the rhesus monkey. *Animal Learning & Behavior*, *2*, 203-206.
- Lindblom, L. L., & Jenkins, H. M. (1981). Responses eliminated by noncontingent or negatively contingent reinforcement recover in extinction. *Journal of Experimental Psychology: Animal Behavior Processes*, *7*, 175-190.
- Lorge, I. (1936). Irrelevant rewards in animal learning. *Journal of Comparative Psychology*, *21*, 105-128.
- Lucas, G. A. (1975). The control of keypecks during automaintenance by prekeypeck omission training. *Animal Learning & Behavior*, *3*, 33-36.
- Mackintosh, N. (1974). *The psychology of animal learning*. New York: Academic Press.
- Morgan, M. J., & Nicholas, D. J. (1979). Discrimination between reinforced action patterns in the rat. *Learning and Motivation*, *10*, 1-22.
- Notterman, J. M., & Mintz, D. E. (1965). *Dynamics of response*. New York: Wiley.
- Pearce, J. M., Colwill, R. M., & Hall, G. (1978). Instrumental conditioning of scratching in the laboratory rat. *Learning and Motivation*, *9*, 255-271.
- Peden, B. F., & Liddell, B. (1983, May). *The paws that refresh: A preliminary attempt to condition self-grooming and other-grooming by rats*. Paper presented at the ninth annual convention of the Association for Behavior Analysis, Milwaukee, WI.
- Pliskoff, S. S., & Gollub, L. R. (1974). Confidence lost and found, or, is the organism always right? *Psychological Record*, *24*, 507-509.
- Pryor, K. W., Haag, R., & O'Reilly, J. (1969). The creative porpoise: Training for novel behavior. *Journal of the Experimental Analysis of Behavior*, *12*, 653-661.
- Rawson, R. A., Leitenberg, H., Mulick, J. A., & Lefebvre, M. F. (1977). Recovery of extinction responding in rats following discontinuation of reinforcement of alternative behavior: A test of two explanations. *Animal Learning & Behavior*, *5*, 415-420.
- Rosenblum, L. A., Kaufman, I. C., & Stynes, A. J. (1966). Some characteristics of adult social and autogrooming patterns in two species of macaque. *Folia Primatologica*, *4*, 438-451.
- Seligman, M. E. P., & Hager, J. L. (1972). *Biological boundaries of learning*. New York: Appleton-Century-Crofts.
- Seyfarth, R. M. (1980). The distribution of grooming and related behaviours among adult female vervet monkeys. *Animal Behaviour*, *28*, 798-813.
- Shettleworth, S. J. (1973). Food reinforcement and the organization of behaviour in golden hamsters. In R. A. Hinde & J. Stevenson-Hinde (Eds.), *Constraints on learning: Limitations and predispositions* (pp. 243-263). New York: Academic Press.
- Shettleworth, S. J. (1975). Reinforcement and the organization of behavior in golden hamsters: Hunger, environment, and food reinforcement. *Journal of Experimental Psychology: Animal Behavior Processes*, *1*, 56-87.
- Shettleworth, S. J. (1978). Reinforcement and the organization of behavior in golden hamsters: Pavlovian conditioning with food and shock unconditioned stimuli. *Journal of Experimental Psychology: Animal Behavior Processes*, *4*, 152-169.
- Shettleworth, S. J., & Juergensen, M. R. (1980). Reinforcement and the organization of behavior in golden hamsters: Brain stimulation reinforcement for seven action patterns. *Journal of Experimental Psychology: Animal Behavior Processes*, *6*, 352-375.
- Sidman, M., & Fletcher, F. G. (1968). A demonstration of auto-shaping with monkeys. *Journal of the Experimental Analysis of Behavior*, *11*, 307-309.
- Skinner, B. F. (1938). *The behavior of organisms*. New York: Appleton-Century-Crofts.
- Skinner, B. F. (1953). *Science and human behavior*. New York: Macmillan.
- Spetch, M. L., Wilkie, D. M., & Skelton, R. W. (1981). Control of pigeons' keypecking topography by a schedule of alternating food and water reward. *Animal Learning & Behavior*, *9*, 223-229.
- Stone, W., Lyon, D. O., & Anger, D. (1978). Suppression of postpellet licking by a Pavlovian S+.

- Bulletin of the Psychonomic Society*, **12**, 117-119.
- Struhsaker, T. T. (1967). Social structure among vervet monkeys (*Cercopithecus aethiops*). *Behaviour*, **29**, 83-121.
- Thorndike, E. L. (1911). *Animal intelligence: Experimental studies*. New York: Macmillan.
- Weber, I. (1973). Tactile communication among free-ranging langurs. *American Journal of Physical Anthropology*, **38**, 481-486.
- Williams, D. R., & Teitelbaum, P. (1956). Control of drinking behavior by means of an operant-conditioning technique. *Science*, **124**, 1294-1296.

Received June 29, 1983
Final acceptance June 19, 1984