*SUPPRESSION OF RANDOM-RATIO AND
ACCELERATION OF TEMPORALLY SPACED
RESPONDING BY THE SAME
PREREWARD STIMULUS IN MONKEYS¹*

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A 1-min tone and light signal that preceded two free pellets of food suppressed the random-ratio responding of four rhesus monkeys, but accelerated the same subjects' responding on a differential-reinforcement-of-low-rate schedule in separate sessions. Both schedule-specific interactions occurred during the first presentations of the signal that previously had been paired with food outside the operant sessions. Thus, neither effect was adventitiously produced. In two subjects, both the direction and magnitude of the prereward change in differential-reinforcement-of-low-rate responding appeared related to baseline response rates: the more rapid the baseline responding, the less was the acceleration during the signal. Suppression and acceleration did not appear as dichotomous effects with separate parameters, but as related effects at least partly determined by the characteristics of the baseline operant performance.

A wide variety of alterations in operant performance, ranging from twofold acceleration in response rate to complete suppression, have been recorded in the presence of stimuli that signal impending noncontingent rewards. The suggestion of this paper is that to some extent, the degree and even direction of these interactions may depend upon the characteristics of the behavior upon which the prereward stimuli are superimposed.

As pointed out initially by Millenson (1967) concerning preaversive warning stimuli, but which now seems to hold equally well for prereward stimuli, it is interesting that such stimuli occasion behavioral adjustments that are rarely useful in the animal's environment. Usually, the behaving subject is afforded no control over the superimposed stimulus or its paired noncontingent reward, yet often the animal behaves in a manner that causes it to miss some baseline reinforcers that would have been obtained, had the signal been ig-

nored. During prereward stimuli, animals have been reported to respond faster on paced timing schedules (Henton and Brady, 1970; Herrnstein and Morse, 1957) and slower on unpaced variable-interval schedules (Azrin and Hake, 1969; Hake and Powell, 1970; Meltzer and Brahlek, 1970; Miczek and Grossman, 1971; Van Dyne, 1971), missing reinforcements in both cases. Animals have also been reported to pause more frequently in free operant avoidance responding during prefood signals, thereby incurring otherwise avoidable shocks (Bull, 1970; Davis and Kreuter, 1972; Henton, 1972). This is not to say that the loss of baseline reinforcements is an essential requisite of prereward interactions, for the latter still occur when a consistent rate of reinforcement, independent of the subject's response rate, is assured during the signal. As an example, a stimulus (CS) previously paired with positive reinforcement (US) increases responding in operant extinction, where the rate of reinforcement is consistently zero in CS and non-CS periods (Estes, 1948; Krystal, 1970).

Although the cumulative evidence from various studies suggests that both the direction and magnitude of prereward interactions may depend upon certain properties of the baseline schedule of reinforcement (*e.g.*, Azrin and Hake, 1969; Henton and Brady, 1970; Herrnstein and Morse, 1957; Pliskoff, 1961), it has been difficult to sort out contrasting prereward effects strictly in terms of schedule differences.

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These diverse prereward effects have been recorded in similarly diverse species, from Old World monkeys to rats and birds. Studies have differed in terms of such Pavlovian variables as the duration and modality of the CS, type and magnitude of the US, scheduling and number of CS-US pairings, and in the prevention of accidental correlations between the measured operant and the noncontingent reward.

The present experiment examined the effects of the same prereward stimulus upon two different schedule performances in the same subjects. Four rhesus monkeys were trained to press a nose key for food pellets delivered on a random-ratio schedule in one session each day, and to press a lever to produce similar pellets on a differential-reinforcement-of-low-rate (DRL) schedule in a separate session. Superimposing a prefood stimulus upon the DRL performance essentially replicated the procedures of Herrnstein and Morse (1957) and of Henton and Brady (1970), which previously resulted in accelerated CS responding. The random-ratio sessions extended the prereward paradigm to a relatively high-rate performance, which by analogy to the preaversive case (Blackman, 1968b), might be expected to lead to suppressed CS responding.

METHOD

Subjects

Four male rhesus monkeys (*Macaca mulatta*) were studied. These animals had previously served in a 1-yr study of random-ratio schedule control of nose-key pressing (Kelly, 1967). The monkeys were in good health throughout the experiment and weighed the following at its close: Monkey A, 6.4 kg; Monkey B, 8.1 kg; Monkey C, 6.9 kg; and Monkey D, 6.5 kg.

Apparatus

Each monkey was permanently restrained in a Plexiglas primate chair enclosed within an individual sound-attenuating booth. The response lever used during DRL sessions was mounted upon the waistplate of the chair, 15 cm (6 in.) directly in front of the monkey. The lever could be activated by exerting a dead weight force of 275 to 330 g (2.8 to 3.3 N) through a 1.5-cm (0.75 in.) excursion, a total

minimum work requirement of approximately 44×10^4 ergs (0.044 J). A transilluminated, clear plastic nose key used during random-ratio sessions was mounted on the neckplate, 8 to 10 cm (3.75 to 4 in.) to the right of the monkey's head. The key moved very little when pressed and could be activated by a lateral force of approximately 310 to 385 g or 3.1 to 3.8 N (range for the four keys). Food reinforcers were Dietrich and Gambrill 750-mg whole-diet pellets delivered through a chute located next to the nose key. A 1-sec pure-tone feedback accompanied every operation of the pellet dispenser. Aside from one piece of fruit offered three times a week, all food was earned during sessions.

Water was available to the monkey at all times, and was delivered in 0.75-sec squirts of 5 ml each through a spout mounted 10 cm (4 in.) to the left of its head. The monkey produced the water by pressing a nose key next to the spout. It was identical to the random-ratio key, but located on the opposite side of the subject's head. As a result, it was not physically possible for a monkey to work for, or to receive water while it was engaged on the random-ratio key. The same was not true when the subject was working on the DRL lever, which it manipulated with its forepaw. However, this did not seem to represent an important difference between the random-ratio and the DRL contingencies, since the monkeys never worked simultaneously on the DRL lever and the water key.

The main houselight was a 6-W fluorescent bulb mounted on the rear wall directly behind the subject's head. Adjacent to the houselight was a 3-ohm speaker used to present the auditory component of the CS, a 600-Hz pure tone. A red-jewelled panel light, mounted directly in front of the subject's face at eye level, was flashed 1-sec on, 1-sec off as the other component of the CS. Twenty-four hour scheduling and recording was accomplished by a mixture of relay and transistor equipment located in an adjacent room.

Procedure

Random-ratio training. Before the present study, each monkey had experienced 750 random-ratio sessions scheduled on a seven-day-per-week regimen of two 1-hr sessions every day, the first from 9 to 10 a.m. and the second from 5 to 6 p.m. The sessions were signalled

by a dimming of the main houselight. The schedule value used in the present experiment was the same as that last experienced by the monkeys for 25 preceding days. It specified a uniform probability of reinforcement of $P = 0.0125$ for every key press. Thus, on the average, one of every 80 responses produced a food pellet.

DRL training. With the booth fully illuminated and in the presence of a loud white-noise background, each monkey was shaped to press the lever with its right forepaw. Establishing a response of consistent topography required four to 10 days. Random-ratio sessions were suspended during this and subsequent DRL training. Next, each monkey was exposed to 50, 1-hr long DRL sessions which were signalled by white noise and scheduled at the rate of five per day during alternating hours from 10 a.m. through 7 p.m. On the DRL schedule, every lever press produced a pellet of food, provided it followed the preceding press by at least the specified minimal interval. For the first five training sessions, the interval was 15 sec and for the next five sessions, 30 sec. Thereafter, the DRL value was increased to 45 sec, where it remained for all subjects, except Monkey D, throughout the rest of the 50 training sessions and the experiment. After training at the DRL 45-sec value, Monkey D was returned to DRL 30-sec during the experiment so as to equate approximately its rate of DRL reinforcements to that of the other subjects. For the same reason, Monkey B was returned to DRL 30-sec for the final three days of the experiment.

Final baseline schedules. For two days before the experiment, the monkeys were run on their final schedules. From 9 to 10 a.m., the houselights were dimmed and the monkeys were allowed to press their nose keys on the random-ratio schedule. From 5 to 6 p.m., the white noise was turned on and the monkeys lever pressed for food on the DRL schedule. The schedules were arranged on different manipulanda and at separate times to minimize interactions between them. Although both manipulanda were continuously present in the chamber, the monkeys rarely made either response between sessions, or the wrong response during a session. The highest number of inappropriate nose-key presses during a DRL session was eight, while the most lever pressing during a random-ratio session was

one response. No inappropriate responses were observed during prereward stimuli.

Day 1. Pairings off-the-baseline. The first 30 CS-US pairings were performed outside the food sessions to avoid accidental correlation between the US and operant responses. The CS was a flashing red light that was paired after 1 min with two free food pellets (US) of the same sort used to reinforce the baseline performances. On Day 1 of the experiment, pairings 1 to 10, spaced 5 min apart, took place midway between the two operant sessions. Pairings 11 to 30, similarly spaced, were presented 2 hr after the evening DRL session.

Day 2. Pairings on-the-baseline. To balance among the four subjects the contingencies in force when the prereward stimuli were introduced upon the baseline performances, six 1-min CS-US pairings were superimposed upon only one of the two operant sessions of each monkey. For Monkeys C and D, the trials occurred during the seventh, sixteenth, twenty-fifth, thirty-fourth, forty-third, and fifty-second minutes of their morning random-ratio sessions. For Monkeys A and B, the trials occurred during the corresponding minutes of their evening DRL sessions.

Days 3 and 4. Pairings both on- and off-the-baseline. All monkeys received six prereward trials during both operant sessions. In addition, they received 10 CS-US pairings off-the-baseline at midday in between the operant sessions, a total of 22 light-food pairings per day.

Days 5 to 11. Compound light and tone CS for all pairings. To increase the discriminability of the CS, particularly during random-ratio sessions when the monkeys were required to move their heads continuously to respond on the nose key, a 1-min 600-Hz pure tone was added to the flashing-light CS. Each monkey continued to receive 22 CS-US pairings per day.

Days 12 to 14. Pre-feeding control for deprivation. Because of the different deprivation times that preceded the two daily sessions, namely 15-hr overnight deprivation before random-ratio sessions as opposed to only 7 hr before DRL sessions (excluding off-the-baseline pairings), the monkeys were fed a calorie-rich meal 1 hr before each session for three days. During each prefeeding, a monkey received one-half a peeled banana and 10 cc of "tangoo", a creamy, blenderized mixture of peanut oil, evaporated milk, raw eggs, ba-

nanas, and powered orange-flavored Tang. Until this phase of the experiment, the monkeys normally received from 120 to 160 food pellets each day, for an average diet of approximately 588 Kcal. The caloric value of each prefeeding was about 432 Kcal, almost double the amount that any monkey earned during the following operant session. Midday off-the-baseline pairings were discontinued.

In all, throughout the experiment, each monkey experienced 270 CS-US pairings, of which 150 occurred during operant sessions and 120 off-the-baseline.

RESULTS

The immediate and enduring effects of the CS were to suppress responding when superimposed upon random-ratio sessions, but to accelerate responding when superimposed upon DRL performance. The baseline-specific effects were not adventitiously produced, occurring on the first baseline trials in all four animals. For the most part, disruptions persisted in initial form for the duration of the experiment, and were impervious to manipulations of food-deprivation levels.

Figure 1 presents the session-by-session effects of the CS upon both baselines throughout the experiment. The measure adopted in this figure and in the succeeding tables is the per cent change in response rate during the CS relative to the average control rate in the absence of the CS. In calculating the latter, the first and the last 3 min of each session were excluded. The per cent change measure is identical, except the decimal point, to the Hunt, Jernberg, and Brady (1952) inflection ratio, $b-a/a$, where a = control rate, and b = CS rate. Several trends can be identified in all four subjects in Figure 1. First, random-ratio responding was suppressed, while DRL responding was enhanced, during the CS. Second, both effects were immediate and apparently unrelated to any accidental correlation between the US and either of the two baseline operants. During the first CS test sessions on Days 2 and 3, random-ratio response rates of Monkeys A-D respectively slowed by 25, 24, 43, and 95%. Upon first presentations of the CS during DRL sessions, the same monkeys increased their response rates by 85, 34, 66, and 11%. As a result of the balanced design on Day 2, Monkeys A and B first experienced the

newly conditioned CS while lever pressing on the DRL schedule, whereas Monkeys C and D

Fig. 1. Differential interactions of prereward CSs with DRL and random-ratio performances of four rhesus monkeys. The zero point on each ordinate scale represents a non-CS control rate for a full 1-hr session, excluding the first and last 3 min. Each bar shows the average rate change during six 1-min CSs. On Day 2, the CS was presented only during DRL sessions for Monkeys A and B, and only during random-ratio sessions for Monkeys C and D. Sessions missed because of equipment failures or illness of a monkey are noted by asterisks.

were nose-key pressing on the random-ratio schedule. Since free food pellets had never been presented previously during sessions, the immediate DRL acceleration of the former monkeys and random-ratio suppression of the latter were evidently related to those signal properties conditioned to the CS during the preceding CS-US pairings and not to chance pairings of the US with either a pause in random-ratio responding or a spurt in DRL responding.

Figure 1 also suggests that the schedule-specific effects of the prereward signal were not due to the differing conditions of deprivation under which the random-ratio and DRL schedules were normally maintained. Despite being fed a sizable meal only 1 hr before every session (right-hand panel of Figure 1), all monkeys continued to show the characteristic suppression in random-ratio responding, coupled with acceleration of DRL responding. Interestingly, these attempts to satiate the monkeys seemed to have had negligible effects not only upon prereward interactions, but upon the baseline response rates as well. These are given in Table 1, along with the corresponding rates of reinforcements for each session throughout the experiment. Since the baseline response rates in Table 1 are also the control rates from which the inflection ratios in Figure 1 were derived, the average CS response rates

of each session can be calculated by multiplying the baseline values given in Table 1 by the corresponding percentages from Figure 1.

Figure 2 presents the complete cumulative records for the first sessions during which each subject was exposed to prereward signals. Noteworthy in these records is both the immediacy with which the previously conditioned stimuli differentially affected the baselines and also the within-CS patterns of those disruptions, particularly during DRL sessions. On a number of these initial CS trials, accelerated DRL responding appeared most pronounced early in the CS interval. This negatively accelerated pattern appeared more often in the cumulative records of succeeding days, and its recurrence seems to support the notion that the CS acceleration was not superstitiously conditioned. In Figure 3, the cumulative records from a later day in the experiment are presented for the two subjects that showed the highest per cent acceleration in DRL responding. After 185 CS-US pairings, the DRL acceleration for Monkeys A and C still often appeared to be greatest during the early part of the CS. By the same stage in the experiment, the DRL acceleration of the other two subjects had attenuated considerably, particularly Monkey B, and within-CS response patterns were unremarkable.

Table 1
Baseline Rates of Responding per Minute (R) and Reinforcements Earned per Session (S^r)

Day	Monkey A				Monkey B				Monkey C				Monkey D			
	Random Ratio		DRL 45 sec		Random Ratio		DRL 45 sec ^b		Random Ratio		DRL 45 sec		Random Ratio		DRL 30 sec	
	R	S ^r	R	S ^r	R	S ^r	R	S ^r	R	S ^r	R	S ^r	R	S ^r	R	S ^r
1	94	78	1.3	53	104	93	3.0	7	65	61	2.0	26	47	40	6.0	18
2	95	91	1.8	37	107	98	3.1	6	51	56	2.4	19	57	50	7.5	12
3	90	84	1.9	28	124	104	3.1	4	61	55	2.7	22	61	39	6.7	14
4	86	86	1.6	20			4.1	6	55	43	2.5	24	55	42	1.7	24
5	87	91	1.3	28	114	101	3.3	11	60	42	2.3	35	60	47	3.1	18
6	81	87	1.1	45	121	107	4.0	4	53	57	1.6	36	66	41	8.7	9
7	86	76	0.2		132	100	3.6	11	57	53	2.1	22	63	55	7.9	34
8	89	96	1.4	18	69	51	4.0	3	54	43	1.7	30	53	51	8.5	26
9	89	88	1.4	34	119	80	5.5	1	53	48	2.0	34	68	46	9.3	26
10	85	98	1.4	43	84	51	5.0	2	58	50	1.9	30	60	52	6.4	38
11	92	101	1.1	46	112	82	5.3	10	48	44	1.8	22	64	47	10.4	22
12	92	98	0.2 ^a		112	83	4.9 ^b	10 ^b	60	32	1.7	36	75	46	11.1	30
13			0.9	39	122	93	4.4 ^b	17 ^b	60	42	1.9	20	85	53	7.3	40
14					101	63	4.7 ^b	18 ^b	62	44	1.6	34	68	61		

Note.—Empty cells indicate either equipment malfunction or illness of a subject.

^aMonkey responded for food, but appeared ill and did not eat pellets.

^bMonkey B shifted to DRL 30-sec on Days 12 to 14.

Fig. 2. Complete cumulative records of the first DRL and first random-ratio session during which monkeys were exposed to a previously conditioned stimulus. Onset of the CS is indicated by straight arrows below the record. The pen was offset throughout the 1-min CS, and two non-contingent food pellets were delivered at the curved arrows. Contingent reinforcers are indicated by downward deflections except during the CS, when they appear as upward deflections. The low-rate records are from DRL sessions, and the high-rate records from random-ratio sessions. The upper record of each pair is from Day 2 of the experiment, the lower record from Day 3.

Throughout the experiment, Monkeys A and C increased their DRL rates during CS trials by an average of 128 and 82% respectively, as opposed to increases of only 8 and 14% for Monkeys B and D. Table 2 indicates

that Monkeys A and C also proved to be the slowest and most efficient DRL responders, which suggests that either response rate, reinforcement rate, or both variables may be parameters of the prereward interaction. Table 2

Fig. 3. Cumulative records of the DRL sessions of Day 9 for the two monkeys that showed the most pronounced rate increases during the CS. CS onset is indicated by a straight arrow below the record. The pen remained offset throughout the CS and two non-contingent food pellets were delivered at the curved arrows. Contingent reinforcements are indicated by downward deflections except during the CS, when they appear as upward deflections of the pen. Both records are 1-hr long.

Table 2

Overall changes in CS response rates compared with control rates of responding and total reinforcements earned on two schedules.

Subject	RANDOM RATIO			DRL			Total Pellets Earned per Day ^a	Percent of Diet Earned in DRL
	Responses per min	Pellets per hour	Change in CS Rate	Responses per min	Pellets per hour	Change in CS Rate		
A	87.7	90.5	-34.8%	1.19	33.8	+127.7%	124.3	27.1
B	110.0	83.2	-26.0	4.23	7.9	+8.2	91.1	8.6
C	56.3	40.7	-25.9	2.02	28.8	+82.2	69.5	41.4
D	64.2	48.5	-41.9	7.37 ^b	22.5 ^b	+13.7	71.0	31.6 ^b

^aDoes not include non-contingent pellets delivered during CS-US pairings.

^bDRL 30-sec schedule for Monkey D, all other subjects DRL 45-sec.

reveals that the lower a subject's reinforcement rate on DRL, the less exaggerated was the acceleration of response rate during the CS. This held true not only for the percentage measures of responding noted here and previously in Figure 1, but also for absolute changes in DRL responding. An extreme example of this relation was Monkey B, whose poorly timed DRL responding occasionally resulted in its receiving as few as one or two food pellets during a full 1-hr session (see Table 1, column 8). Yet, during CS trials that involved 12 non-contingent pellets, its responding was the least accelerated of any subject. On the other hand, Monkey A, the most highly reinforced, showed the most acceleration during the CS. The equivalent summary data for random-ratio sessions in Table 2 disclosed no similar relations among subjects.

Since prereward-DRL interactions were correlated across subjects with reinforcement rates, the weak CS acceleration evidenced by Monkeys B and D might have been related to their high, inefficient rates of DRL responding. This supposition is supported by the data of Figure 4, which shows scattergrams of these two subjects' daily control DRL rates plotted against prereward rate changes on the same days. From the spread of these data (and also from Table 1) it seems clear that the daily DRL rates of Monkeys B and D varied widely. Further, the different baseline rates appeared to correlate inversely with response rate changes during the interspersed CS trials. Not only the severity, but also the direction of the prereward disruption appeared related to the prevailing control rate. Thus, on days when DRL responding was slow, acceleration during the CS was pronounced; whereas on days when baseline responding was more rapid, CS ac-

Fig. 4. Scattergrams correlating prereward interactions with control baseline DRL rates for two monkeys. Each point compares the non-CS control rate during a 1-hr session (excluding the first and last 3 min) with the average rate change during six 1-min CSs. Sessions 12 to 14 have been omitted from Monkey B's graph, because they were scheduled with a different DRL interval.

celeration was usually attenuated. On occasion, both monkeys even showed partial suppression during CS trials, these sessions marked by the highest baseline rates. The product-moment correlation coefficient of CS-rate changes to control rates was -0.89 for Monkey B and -0.48 for Monkey D. Thus, approximately 79% of the variance in Subject B's prereward responding and 23% of Subject D's could be accounted for by taking the DRL rate into consideration. If the one outlying point in Monkey D's plot is excluded, $r = -0.83$, which accounts for roughly 67% of the remaining variance. The other subjects were not included in Figure 4 because they did not show a similarly wide range of DRL rates. Daily variations in the magnitude of their prereward accelerations were unrelated to the minor variations in their consistently low baseline DRL rates. The interested reader, however, can construct scattergrams for the excluded monkeys by matching the baseline rates presented in Table 1 with the corresponding inflection ratios of Figure 1. In a similar analysis of random-ratio interactions, no equivalent correlations were noted between any subject's control random-ratio rates and the severity of prereward suppression.

DISCUSSION

The principal finding was that random-ratio responding was suppressed but DRL responding was accelerated by the same prereward stimulus. Neither effect reflected an accidental correlation between free reinforcers and operant responding, nor was the direction of either effect dependent upon a particular level of food deprivation. Both the direction and magnitude of DRL prereward interactions appeared related to control DRL rates.

The within-CS patterns of accelerated DRL responding often noted in this experiment differed from those previously described in pigeons by Herrnstein and Morse (1957) and in two rhesus monkeys by Henton and Brady (1970). Their subjects often accelerated with increasing speed during CSs as the terminal free food reinforcers approached. This "scaloped" pattern has raised some suspicion (Azrin and Hake, 1969; Van Dyne, 1971) that CS responding might have been linked superstitiously to the US in these studies, especially since all CS-US pairings were carried out dur-

ing DRL sessions. The present observations suggest, however, that acceleration is a common, non-accidental form of interaction between a prereward CS and a low-rate DRL performance. With the exception of a report by Finnocchio (1963), most studies involving preaversive stimuli have found suppression of DRL responding (Blackman, 1968*b*; Leaf and Muller, 1964) except when shocks of very low intensity have been used (Blackman 1968*a*). Thus, the accelerative effect of a prereward CS upon DRL responding seems to represent an exception to the long list of similarities noted thus far between the behavioral properties of prereward and preaversive stimuli (Azrin and Hake, 1969; Kelly, 1973).

Another difference between the effects of positive and negative CSs is implied by the failure in the present experiment of changes in deprivation level to affect either of the schedule-specific prereward interactions. This could be taken to conflict with the analogous data of Millenson and deVilliers (1972*b*), who found that partial satiation enhanced pre-shock suppression of a food motivated random-interval performance, while an increase in the sucrose concentration of the baseline reinforcer attenuated suppression. However, unlike Millenson and deVilliers' findings, the prefeedings in the present experiment did not affect control response rates on either random-ratio or DRL schedules. I have also noted this interesting phenomenon in the past, namely, that chaired rhesus monkeys maintained at less than free-feeding weights, respond for food pellets whether starved as briefly as 1 hr or as long as two days. Under the present conditions, the subjects recovered within 1 hr from a feeding that represented more than three-quarters of their normal daily caloric requirement. This may relate to the rhesus monkey's ability to store food pellets for later consumption in its cheek pouches, or to the size of its stomach, which is quite large in comparison to man's and to most other laboratory species (Hartman and Straus, 1961). Whatever the explanation, since the same pellets served both as the baseline reinforcer and as the US, it is understandable that neither prereward interaction was affected by the prefeedings.

The curious counterproductive trend of prereward behavioral adjustments found in prior experiments was found here also. During prereward signals, all subjects behaved on both

schedules in a manner that tended to prevent their sustaining a normal (non-CS) rate of reinforcement. Acceleration in DRL responding biased proficiently timing subjects towards fewer reinforcements, as did slower responding on the random-ratio schedule. The question of the mechanism of such maladaptive effects remains open: what is it that might interact in operant-Pavlovian interaction experiments?

Since suppression has been the most commonly observed effect of both prereward and preaversive stimuli, it has usually been assumed that what interacts with the measured operant is some form of incompatible behavior. Most often, these interfering responses have been postulated to be learned internal "emotional" respondents, which somehow combine to prevent the subject from pressing down on the lever (*e.g.*, Azrin and Hake, 1969; Kamin, 1965). Millenson and deVilliers (1972a) termed this *ad hoc* theory, the "conditioned emotional respondent" hypothesis. However, despite many attempts at measurement (Brady, Kelly, and Plumlee, 1969; de Toledo and Black, 1966; Parrish, 1967; Stebins and Smith, 1964; Zeiner, Nathan, and Smith, 1969), there is virtually no evidence that such responses exist as might be capable of interfering with an animal's skeletal activities, particularly in the case of prereward suppression (Kelly, 1973). Alternatively, Farthing (1971) suggested that superstitious operants conditioned during CS-US pairings and coming under the discriminative control of the CS could also preempt the baseline operant, resulting in suppression. Similarly, a subject might learn certain behaviors that prepare for the US, such as bracing for shock or approaching a food tray. The argument is made that a subject cannot do two things at once, particularly if the skeletal demands of these activities are mutually exclusive. Yet, it is difficult to understand how either superstitious or preparatory prereward operants, which normally interfere with CS responding and produce suppression, would under different test conditions interact with the measured operant to produce reliable acceleration of DRL performance or acceleration of variable-interval performance during long duration CSs (Meltzer and Brahlek, 1970). Essentially, the notion of an interfering response of any origin, operant or respondent, explains only suppression.

Recently, both Estes (1969) and Millenson (1971) have proposed independently that the interactions that produce preaversive suppression may not involve learned, incompatible behaviors, but rather central motivational, or incentive states. To quote Millenson and deVilliers (1972a): ". . . the CER would appear as a kind of negative drive which . . . might be expected to subtract from other positive drives operating at the time of its appearance, in particular the baseline maintenance drive [P. 103]". As they, as well as Kamin (1965), have noted colloquially "the CER pits fear against hunger". However attractive the incentive theory might appear for preaversive suppression, it would certainly appear difficult to extend this explanation to prereward phenomena, particularly to those experimental designs where both the US and baseline reinforcers are qualitatively the same, *i.e.*, where "food pellets are pitted against food pellets". Whatever interacts during such prereward stimuli clearly does not involve the primary reinforcing value of a food pellet, if the only differences between the free and baseline pellets lie in the contingent work required of the subject to obtain them.

Kelly (1972) offered a characterization of prereward interactions, which emphasizes work contingencies. The superimposition of prereward pairings upon any contingent schedule temporarily changes the total work required of the subject or, as Hull (1943) phrased it: "the energy expenditure requirements", to produce a basal level of reinforcement. Instead of reflecting a decline in the reinforcing value of the baseline reinforcer, prereward suppression might represent a shift in the amount of work that a subject will perform to obtain baseline reinforcements, a criterion shift in effort. This hypothesis also encounters difficulty in explaining accelerative prereward interactions with DRL performance, unless the concept of work is broadened to include other dimensions besides muscular movement. Perhaps it is "work" to time, or to withhold a highly reinforced response as a condition for reinforcement.

Finally, the apparent relation of the direction of the prereward interactions of two subjects in the present experiment to their control DRL rates seems to reinforce the suggestion that the time may be near to break with the convenient tradition of treating suppression

and acceleration as binary, opposing behavioral effects. A plus-and-minus distinction is hazardous because it focuses attention categorically upon only one point in the apparently continuous, broad range of interaction effects. In much of the literature, the terms suppression and facilitation have been uncritically treated as antonyms: one a "bad" effect upon behavior, the other "good"; one an interference or disruption of performance, the other an improvement—all implicitly analogous to industrial psychology notions of work output and productivity. Perhaps this approach is justified in attempts to review and codify this confusing literature, such as in those of Rescorla and Solomon (1967) and Brady (1971), but otherwise there appears to be little evidence for perpetuating the pretense. The criticism that might be levelled at the facilitation-suppression dichotomy resembles the argument made against the classical view of the sensory threshold by modern signal-detection theory (Swets, 1961). Much evidence now testifies that suppression and facilitation are not discrete sets of effects with private parameters, but that they are effects related along an orderly continuum that is exposed whenever its proper parameters are manipulated. For example, in addition to the present DRL data, Blackman (1968*b*) related not only the magnitude, but also the direction of the interaction effects of preaversive stimuli to the prevailing baseline response rate and to the rate of reinforcement. Meltzer and Brahlek (1970) reported consistent suppression of rats' variable-interval responding by a 12-sec prereward signal, mixed effects (which averaged out to slight suppression) at 40 sec, and enhanced rates in the presence of a 120-sec CS. Shimoff (1972) reported in monkeys' free operant avoidance responding biphasic patterns of initial acceleration followed by suppressed rates of responding, both consistently occurring within the same preaversive CS.

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