TIME REALLOCATION IN A MULTIRESPONSE ENVIRONMENT: EFFECTS OF RESTRICTING RESPONSE CLASSES

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Four adult male rats were each placed for three hours daily into an apparatus that provided individual compartments for six separate location-defined responses. The available responses consisted of: (1) the opportunity to turn off room lighting, producing darkness; (2) the opportunity to view a female rat; (3) the opportunity to turn off white noise; (4) the opportunity to drink; (5) the opportunity to eat; and (6) "other," representing time in the hallway between compartments. Each subject underwent a series of conditions characterized as an A-B-A-C-A design. Manipulations consisted of the removal of a low-probability response (darkness) and of a high-probability response (escape from noise) in a counter-balanced manner across subjects. The dependent measure for all subjects was the percentage of total session time spent in each compartment. Four predictive rules concerning the redistribution of behavior after response restriction were tested, including the constant-ratio rule, equal time redistribution, the most probable alternative, and the sequential-dependency rule. The results indicate no support for any of the four predictive rules and suggest that empirical assessment of restriction effects is necessary in reinforcement studies involving temporally extended responses.

Key words: time allocation, closed behavior system, multiresponse environments, response restriction, free operants, rats

Recently, several conceptual positions have appeared regarding an organism's distribution of time among a group of alternatives (e.g., Bernstein, 1980a; Bernstein & Ebbesen, 1978; Rachlin, 1980; Rachlin & Burkhard, 1978; Staddon, 1979, 1980). A common theme is the notion that time may be considered a resource to be allocated to various activities, and that the principles of economics can be applied to time allocation in the same way as those principles deal with relationships among commodities. These analyses also share certain general assumptions: that it is important to view reinforcement and punishment within the larger context of the overall behavioral repertoire; that

the distribution of time among the repertoire's components in free-access conditions indicates relative preferences for an organism; and that choice between behavioral alternatives is influenced by the relative substitutability of responses (i.e., the extent to which an organism will replace one alternative with another).

In a similar context Premack (1965), Eisenberger, Karpman, and Trattner (1967), and Timberlake and Allison (1974) have demonstrated that the establishment of any reinforcement contingency necessarily involves the restriction of some response (called the contingent response) below its baseline level of occurrence. When a contingency is arranged such that an organism can regain access to the restricted contingent response by engaging in above-baseline levels of the instrumental response, the subsequent increase in instrumental responding is taken as evidence of "reinforcement."

Whenever a behavioral system is "closed," however (that is, when responses are mutually exclusive and exhaustive), the restriction of a response class, necessary for estab-

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lishing a reinforcement contingency, forces the reallocation of time formerly spent engaging in the restricted response class to the remaining response alternatives. A closed system is approximated in learning studies involving temporally extended response classes, because as greater proportions of session time are filled by the instrumental response (such as a holding response) and the contingent response, less session time is available for variations in background responding. Thus, some unrestricted response (or combination of responses) must necessarily increase as the result of restriction effects alone. This can present a problem in defining reinforcement, in that the resulting increases may not reflect the effects of the contingency, but rather the effects of simple response restriction.

The ability to predict the manner in which time is reallocated to other responses in a closed behavioral system following the restriction of one response alternative is of significant value to psychology, not only because it allows precise prediction of forthcoming behavior, but also because it provides a method for separating contingent effects from restriction effects. Such knowledge prior to the establishment of a contingency would thus provide a necessary control in reinforcement studies involving temporally extended responses, as Knapp (1976) has noted. Unfortunately, a simple rule for predicting restriction effects is not currently available.

Certain predictive rules for separating restriction and contingent effects have been suggested. Following from Luce's (1959) choice axiom, the "constant-ratio rule" predicts that time made available by response restriction will be redistributed among independent response classes in direct proportion to their baseline levels. Rachlin and Burkhard (1978) used this rule in their temporal triangle model as the point against which to assess reinforcement or response substitution, under the assumption that if restriction of the contingent response (C) has no effect other than to reduce C relative to baseline, the remaining responses

will not change in terms of the proportion of time they occupy.

Bernstein (1980a, 1980b), Bernstein and Ebbesen (1978), and Staddon (1979, 1980), on the other hand, rejected the constant-ratio rule. Instead, Bernstein's research indicated that time reallocation following response restriction is idiosyncratic and must be empirically determined for each subject prior to the introduction of a contingency. This suggests that no single predictive rule can be of value in separating contingent and restriction effects.

Dunham and Grantmyre (1982) offered yet another set of predictive rules. They suggested that when one response is removed due to punishment or restriction procedures, (a) the most probable remaining response will increase disproportionately, and (b) the sequential relationships between pairs of responses established under baseline conditions will influence the reorganization of the response hierarchy in such a way that the response most sequentially dependent on the restricted response will show a tendency to decline also under punishment or restriction conditions. Remaining response alternatives will not significantly deviate from their baseline levels. When these two rules conflict, Dunham and Grantmyre predict they will interact with offsetting effects.

Both Luce's constant-ratio rule and Dunham and Grantmyre's most-probable-alternative/sequential-dependency rules have certain appeal because they provide a potential method for assessing restriction effects without resorting to empirical assessment of each subject's restriction hierarchy (as advocated by Bernstein). However, studies examining these predictions differ in methodology and design, and no clear evidence exists allowing an assessment of their relative predictions.

The present study established a closed behavioral system and used rats as subjects to test the predictions of the constant-ratio rule, the sequential-dependency rule, the most-probable-alternative rule, and the possibility that available time is redistributed equally among remaining response

alternatives, following simple restrictions of high- and low-probability response categories.

METHOD

Subjects

Four experimentally naive male albino laboratory rats (Sprague-Dawley derived), six to nine months of age at the beginning of the experiment, served as subjects. Subjects were housed in individual cages without access to food or water, which were available only in the experimental apparatus. At the time of each experimental session, each subject had been deprived of food and water for a 21-hr period. Each subject weighed at least 350 g when the experiments began.

Apparatus

The apparatus (Figure 1) rested on a table in an isolated room; it was a multiresponse chamber consisting of five plywood compartments connected by a passageway. Each compartment had a plywood floor (0.46 m by 0.61 m) hinged at the side opposite the entrance, permitting depression when a subject entered a compartment. Beneath each floor three microswitches closed when the floor was depressed 3.2 mm. Three compression springs provided tension to return the floor to its original position when weight was removed.

The passageway was 0.15 m wide and access to any compartment was provided by a 0.15-m entrance. A plywood door could be inserted across the entrance, blocking access to a compartment. The ceiling was wire fencing on a wooden frame. An exhaust fan, located on the door of the apparatus/equipment room, was on constantly throughout sessions to provide air circulation.

Each compartment contained stimulus support for one defined type of behavior. Originally, in Compartment 1, the ceiling was covered with plywood such that when the ceiling was lowered, the compartment was darkened. Because of concern that the wooden ceiling of Compartment 1 also served to reduce the intensity of the white

noise present in the experimental room while a subject remained in that compartment, the ceiling over Compartment 1 was removed. Microswitches under the floor of Compartment 1 were subsequently connected to a relay that, when operated, turned off the 25-W incandescent lamp that illuminated the entire experimental room during all sessions. One wall of Compartment 2 was a glass panel providing a view of one adult female rat housed in a cage placed next to the apparatus. Entrance into Compartment 2 turned on a 15-W light located over the female's cage (to enhance visibility). Entrance into Compartment 3 turned off the 88-dB white noise that was otherwise constant throughout the experimental room. In Compartment 4, a water tube was centered in the rear wall, allowing unconstrained access to fresh tap water. In Compartment 5, a food dish was attached to the rear wall, allowing unconstrained access to 45-mg Bio-Serv food pellets. In all, six different location-defined responses were thus available and recordable:

- Compartment 1—darkness (escape from light)
- Compartment 2—opportunity to observe female rat
- Compartment 3—quiet (escape from white noise)
- Compartment 4—access to water
- Compartment 5—access to food
- Passageway 6—movement between compartments

Electromechanical equipment located adjacent to the apparatus, with running-time meters accurate to the nearest 0.01 min, recorded the total duration an animal spent in any compartment, as well as total session time. Passageway duration was determined by adding compartment durations and subtracting this time from total session time. A five-pen event recorder provided data on frequency of room entrances and the sequence of behavioral patterning during selected sessions for the sequential-dependency analysis.

Fig. 1. Floor diagram of the experimental apparatus.

For all phases of study, animals received food, water, darkness, and the opportunity to view other animals only in the experimental apparatus. Because all subjects entered the apparatus daily, olfactory stimuli were impossible to eliminate. The apparatus was cleaned after each animal's use and was sponged with a disinfectant/deodorizer daily.

Experimental Design

All four subjects underwent a sequence of conditions constituting a single-subject A-B-A-C-A design. The experimental manipulations consisted of the restriction of a high-probability response and a low-probability response, each followed by a return to baseline conditions. The determination of high- and low-probability responses was made during the first baseline phase. A "high-probability" response was defined as the most likely response, in terms of duration, as averaged across sessions during the baseline phase. For all subjects, the highest-probability response was turning off white noise (Compartment 3). A "low-probability" response was defined as a response occupying

not less than 5% or more than 20% of total session time, averaged across baseline sessions. This definition was chosen to provide an above-zero amount of allocation time yet not more than one-fifth of the total. For all subjects, the low-probability response was that of turning off the light in Compartment 1.

Because the decision to remove the plywood ceiling in Compartment 1 (in favor of turning off the room lighting upon entry) was made after the experiment began, an additional baseline phase was added to assess the effects of this change on those subjects with experience in Compartment 1 prior to that change. This resulted in the addition of a baseline period for Subjects W, X, and Z.

General Procedure

All subjects were run for 3 hr daily, 7 days per week. Prior to each session, all timers were set to zero and both white noise and the experimental room light were turned on. Animals were periodically weighed just prior to and immediately following the session. If a compartment restriction was scheduled, a panel was fitted at the entrance of the

restricted compartment. Subjects were then released at one of three different points in the hallway (release points were changed daily), the apparatus lid was lowered, and the session timer was started.

At the conclusion of each session, the experimenter removed the animal and recorded data from the timers. The time spent in each compartment was transformed to a percentage of total session time. Residual time was recorded as "passageway." All experimental conditions lasted at least 15 session-days, although some conditions were extended an additional 1 to 6 days because of the loss of an occasional day through equipment failure.

Data for sequential-dependency analyses were recorded with the 5-pen event recorder during sessions immediately prior to changes in experimental conditions. The event records from these sessions were transformed into a series of numbers portraying the order of compartment entries during the session. Within the sequence chain, a response could occur several times sequentially (i.e., follow itself in the chain), provided that 5 s elapsed between exit from a compartment and re-entry into the same compartment, unless another compartment was entered in the intervening period. Exit from and re-entry into the same compartment in less than 5 s were not considered separate responses in the sequence.

For the present study, 95% confidence intervals were constructed around all condition averages as well as the averages for each one-third of the total number of sessions for each of the various conditions. The confidence intervals should contain the true response mean in 95% of the cases. Response levels were judged to be different if there was no overlap between these confidence intervals. Response variability was judged to have changed only if the standard deviation for a sample of response times increased or decreased by more than an arbitrary 25% compared to the standard deviation of a similar sample of response times.

RESULTS AND DISCUSSION

Figures 2 and 3 display the response hierarchies across experimental conditions for each subject. All subjects began with similar baseline hierarchies, and these were generally recoverable after each return-to-baseline phase, with only one instance in which escape from noise did not recover its hierarchy status. Each successive return-to-baseline phase, however, was characterized by increasing response variability for three of four subjects, indicating that the restrictions had a disruptive effect. The data also indicate a tendency for the manipulations to show an effect across the entire study, characterized by a gradual decline in escape from noise and a gradual increase in darkness time throughout the experiment. In general, choosing the opportunity to eat and choosing the opportunity to drink were the most stable responses.

Although baseline response hierarchies were similar among subjects, restriction effects were not. The time freed by restriction of the low-probability response (darkness) was absorbed into the high-probability alternative (escape from noise) for Rat W, but was redistributed to remaining response alternatives for Rats Y and Z; it produced complex changes for Rat X (including a decrease in the high-probability response as well as increases in remaining responses). The restriction of the high-probability response, escape from noise, resulted in disproportionate increases in darkness and hallway time for Rats W, X, and Y, but Rat Z showed greater increases in hallway and Compartment 2 time (opportunity to view a female rat).

Table 1 shows the obtained values, and the values predicted by various rules, following the restriction of the low-probability (A) and high-probability (B) responses for each subject. Within this behavioral system (providing these response opportunities), the data offer no support for the constant-ratio rule. Clearly the rats in this study did not

Fig. 2. Mean response levels and 95% confidence intervals, expressed as a percentage of total session time, for all response categories during each experimental condition, for Subjects W and X. Response categories: 1 = darkness, 2 = view, 3 = escape from noise, 4 = water, 5 = food, 0 = other. Experimental conditions: A* = baseline conditions, Compartment 1 covered with ceiling to provide darkness; A = baseline conditions, Compartment 1 wired to relay to turn off room lighting; B = first response restriction; C = second response restriction.

Fig. 3. Mean response levels for all response categories during each experimental condition, for Subjects Y and Z. Response measures and categories are the same as for Figure 2.

keep relative baseline proportions constant after simple restriction of one response. Perhaps a constant-ratio redistribution requires more extended conditions (although nothing in the present data indicates that this is likely). This finding further indicates that Rachlin and Burkhard may be in error in assessing reinforcement and substitution against a constant I/N ratio, and that Bernstein and Staddon may be correct in not employing the constant-ratio rule in their analyses.

Overall, the data also fail to support the notion that time will be equally reallocated to remaining alternatives. Only in one instance, after restriction of the low-probability response for Subject Y, did this prediction describe the obtained data; however, this removal of the low-probability response left only 6.4% of session time to be reallocated, making tenuous any conclusion of support for equal redistribution. When large proportions of session time were made available by restriction of the high-probability response, equal redistribution did not occur. In addition, the ability of these rules to describe obtained results did not improve when experimental conditions were segmented into thirds, indicating that, at least under the present circumstances, the poor predictive value of these rules was not an artifact of averaging results over sessions.

The most-probable-alternative-response rule of Dunham and Grantmyre (1982) received support in only one of eight restriction phases, with questionable support (tempered by imprecise determination of the most probable alternative) in two additional instances. There was no clear tendency for the most probable unrestricted response to absorb the newly available time. Further, contrary to the assertion of Dunham and Grantmyre, the remaining response alternatives did not remain unaffected, nor retain their baseline levels. The most-probable-alternative-response rule apparently has little or no predictive value under these conditions.

Furthermore, the sequence data gathered with the 5-pen event recorder provide no

support for the sequential-dependency rule, also advocated by Dunham and Grantmyre. Table 2 shows the degree to which any one response was sequentially dependent upon any other response during the baseline sessions prior to the first restriction for each subject. The numbers in the table indicate the probability with which any preceding response (listed in the first column) was followed by any other response (subsequent columns). Thus, reading across the first row in Table 2, darkness for Subject W (prior to the first response restriction) was followed by another entry into Compartment 1 with a probability of .06; it was followed by escape from noise with a probability of .22, and by water with a probability of .11. "Food" never followed darkness during this session. Table 2 also displays the sequential dependencies between all response combinations during the baseline sessions prior to the second response restriction for each subject (second value in each column). There was a tendency, in one of eight restriction conditions, for a sequentially dependent response to decline following the restriction of another response (Subject X, first response restriction: escape from noise declined following restriction of darkness). Over the course of the study, however, this tendency was apparently not determined by the absolute degree of sequential relationship. The one restriction condition supporting the sequential-dependency prediction involved a sequential probability of .38 (Table 2, Subject X, darkness preceding escape from noise); the restriction condition testing the largest sequential dependency, .60 (Table 2, Subject Y, darkness preceding escape from noise), indicated no change in the level of the target response escape from noise.

The lack of support for the Dunham and Grantmyre predictions may be at least partly a function of the large intersession variability in response durations under the conditions of the present experiment. This variability may stem from the number of responses measured (the present study examined six responses; Dunham and Grantmyre examined four), the type of responses

Table 1

(A)

Predicted/Obtained Response Values Following Restriction of Low-Probability Response

	<i>Response Category</i>	<i>Value Prior To Restriction</i>	<i>Obtained Post- Restriction (Limits of 95% Confidence Int.)</i>	<i>Predicted Post-Restriction, Constant-Ratio Rule</i>	<i>Predicted Post-Restriction, Equal Redistribution</i>
<i>Subject W</i>	1 darkness	12.9	— —	— —	— —
	2 view	10.6	10.3 (7.6-13.0)	12.2*	13.2
	3 noise off	47.3	61.1 (57.8-64.4)	54.3	49.9
	4 water	8.2	8.0 (7.4-8.6)	9.4	10.8
	5 food	13.9	11.3 (9.7-12.9)	16.0	16.5
	0 other	7.1	9.1 (6.9-11.3)	8.2*	9.7*
<i>Subject X</i>	1 darkness	7.3	— —	— —	— —
	2 view	6.0	10.8 (8.6-13.0)	6.5	7.5
	3 noise off	55.2	44.4 (42.9-45.9)	59.5	56.7
	4 water	8.5	9.4 (8.4-10.4)	9.2*	9.0*
	5 food	15.1	18.7 (16.8-20.6)	16.3	16.6
	0 other	7.9	16.7 (14.7-18.7)	8.5	9.4
<i>Subject Y</i>	1 darkness	6.4	— —	— —	— —
	2 view	1.4	2.7 (1.7-3.7)	1.5*	2.7
	3 noise off	67.8	68.2 (65.0-71.4)	72.4	69.1
	4 water	8.1	8.7 (7.8-9.6)	8.7*	9.4*
	5 food	9.7	12.0 (10.2-13.8)	10.4*	11.0*
	0 other	6.7	8.3 (6.7-9.9)	7.2*	8.0*
<i>Subject Z</i>	1 darkness	9.1	— —	— —	— —
	2 view	6.0	9.2 (8.3-10.1)	6.6	7.8
	3 noise off	50.2	50.0 (46.0-54.0)	55.2	52.0*
	4 water	8.4	9.0 (8.2-9.8)	9.3*	10.2
	5 food	13.1	14.5 (13.3-15.7)	14.4*	14.9*
	0 other	13.3	17.3 (13.8-20.8)	14.6*	15.1*

(B)

Predicted/Obtained Response Values Following Restriction of High-Probability Response

<i>Subject W</i>	1 darkness	5.5	41.3 (34.8-47.8)	12.3	16.6
	2 view	11.6	12.1 (9.3-14.9)	25.9	22.7
	3 noise off	55.3	— —	— —	— —
	4 water	7.6	10.7 (9.5-11.9)	17.0	18.7
	5 food	13.4	14.1 (11.2-17.0)	29.9	24.5
	0 other	6.7	21.8 (17.1-26.5)	15.0	17.8*
<i>Subject X</i>	1 darkness	18.5	29.4 (18.9-39.9)	32.3*	27.0*
	2 view	5.3	15.2 (10.2-20.0)	9.3	13.8*
	3 noise off	42.7	— —	— —	— —
	4 water	9.7	18.5 (14.6-22.4)	16.9*	18.2*
	5 food	14.1	15.8 (12.7-18.9)	24.6	22.6
	0 other	9.7	21.1 (17.3-24.9)	16.9	18.2*
<i>Subject Y</i>	1 darkness	7.7	46.7 (42.3-51.1)	21.4	20.5
	2 view	4.0	6.0 (4.6-7.4)	11.1	16.8
	3 noise off	64.1	— —	— —	— —
	4 water	7.0	14.1 (13.0-15.2)	19.5	19.8
	5 food	11.2	12.8 (11.1-14.5)	31.2	24.0
	0 other	6.0	20.4 (17.5-23.3)	16.7*	29.5
<i>Subject Z</i>	1 darkness	11.8	16.6 (11.1-22.1)	21.5*	20.8*
	2 view	8.3	18.0 (12.5-23.5)	15.1*	17.3*
	3 noise off	45.0	— —	— —	— —
	4 water	9.2	14.1 (10.8-17.4)	16.7*	18.2
	5 food	12.5	13.0 (11.6-14.4)	22.7*	21.5
	0 other	13.2	38.3 (32.6-44.0)	24.0	22.2

* Indicates predicted values falling within the limits of obtained 95% confidence intervals.

Table 2

Sequential probabilities between all possible combinations of five responses during 3-hour baseline session immediately prior to the first and second response restrictions for each subject. (Rows = preceding response; columns = following response. Each column shows value before first restriction, value before second restriction.)

Subjects	Darkness (1)		View (2)		Escape from noise (3)		Water (4)		Food (5)	
Subject W										
1 Darkness	.06,	.38	.61,	.44	.22,	.06	.11,	.13	.00,	.00
2 View	.13,	.21	.29,	.36	.45,	.36	.06,	.00	.06,	.07
3 Escape from noise	.15,	.40	.26,	.20	.41,	.10	.12,	.30	.05,	.00
4 Water	.33,	.33	.07,	.00	.33,	.33	.07,	.33	.20,	.00
5 Food	.42,	.00	.00,	.00	.00,	.00	.57,	1.00	.00,	.00
Subject X										
1 Darkness	.15,	.50	.31,	.16	.38,	.21	.08,	.08	.08,	.04
2 View	.25,	.16	.20,	.45	.40,	.16	.15,	.10	.00,	.13
3 Escape from noise	.05,	.27	.26,	.23	.32,	.32	.26,	.09	.11,	.09
4 Water	.14,	.08	.29,	.38	.14,	.23	.21,	.23	.21,	.08
5 Food	.20,	.00	.40,	.13	.00,	.25	.40,	.36	.00,	.25
Subject Y										
1 Darkness	.17,	.33	.33,	.07	.46,	.60	.00,	.00	.04,	.00
2 View	.11,	.17	.54,	.33	.36,	.50	.00,	.00	.00,	.00
3 Escape from noise	.36,	.19	.09,	.08	.36,	.38	.18,	.19	.02,	.16
4 Water	.00,	.00	.00,	.00	.64,	.90	.18,	.10	.18,	.00
5 Food	.00,	.33	.20,	.00	.40,	.17	.20,	.38	.20,	.17
Subject Z										
1 Darkness	.08,	.23	.38,	.23	.23,	.15	.23,	.31	.08,	.08
2 View	.53,	.19	.20,	.31	.07,	.31	.13,	.00	.07,	.19
3 Escape from noise	.25,	.21	.10,	.43	.38,	.21	.13,	.14	.06,	.00
4 Water	.00,	.21	.21,	.07	.50,	.29	.29,	.36	.00,	.07
5 Food	.00,	.17	.20,	.17	.00,	.17	.60,	.50	.20,	.00

measured (some response categories, such as food and water, may be more stable than others), or the length of experimental sessions (Dunham and Grantmyre used 20-min sessions, compared to 3-hr sessions in the present research). Because of this variability 95% confidence intervals were constructed around each response mean in the present study, and an arbitrary criterion for change in response level (no overlap in confidence intervals) was used. Through the use of this change criterion, no support for the various predictions emerged. The application of a similar criterion for change to the data of Dunham and Grantmyre, in which no specific change criteria were reported, might have weakened their support for the predictive rules examined.

The predictive rules tested here are by no means exhaustive. Timberlake (1979) employed "highly substitutable responses," 0.1% and 0.4% saccharin solutions, to test

the constant-ratio rule (called the "response competition model"), while noting that "it is unlikely to be appropriate because of the relatedness of the two licking responses" (p. 279). In addition, he assessed a variant of the constant-ratio rule, called the "mixed" model, as well as a "substitution" model, in terms of their value in separating contingent and noncontingent effects of schedule responding, and found none of the models to be adequate for that purpose. Both the "mixed" and "substitution" models require baseline measurement of each response in isolation (i.e., single-baseline procedure). Baseline levels of each response in the present study could not be measured in isolation because in a closed behavioral system such levels would necessarily be 100%. Similarly, Allison (1976) and Lea (1983) offered models that can be used to test behavior reallocation following simple response restriction, but these also require single-baseline mea-

surement of each response class and consequently cannot be assessed in the context of the data reported here.

In conclusion, the present data provide no support for current models seeking to predict restriction effects from a knowledge of baseline response hierarchies. This seems to suggest that Bernstein's insistence on empirical assessment of restriction effects prior to the introduction of a contingency is valid, at least in the absence of cogent alternatives. Unless these effects are assessed before a contingency is instituted, researchers using temporally extended responses are in danger of overestimating the effects of a reinforcement procedure.

Because there is no accepted or standardized methodology for closed-system research, comparison of these results with other studies remains difficult. Previous research examining time reallocation has used various subjects, session lengths, numbers of sessions, and procedures, and has produced conflicting results. It is possible, for example, that the form of time reallocation is dependent on the types of response classes examined. If this is so, the value of predictive rules (such as the constant-ratio rule) will be specific to very constrained circumstances and thus will provide no generally applicable information. The present data at least indicate that, given a closed behavioral system with response classes of different functions and sensory modalities, simple predictive rules of time reallocation do not emerge.

REFERENCES

- Allison, J. (1976). Contrast, induction, facilitation, suppression, and conservation. *Journal of the Experimental Analysis of Behavior*, **25**, 185-198.
- Bernstein, D. (1980a). *Reinforcement and substitution in open and closed human economies*. Paper presented at the Association for Behavior Analysis, Dearborn, Michigan.
- Bernstein, D. (1980b). *Prediction and assessment of reinforcement value in human behavior*. Paper presented at the Association for Behavior Analysis, Dearborn, Michigan.
- Bernstein, D. J., & Ebbesen, E. B. (1978). Reinforcement and substitution in humans: A multiple-response analysis. *Journal of the Experimental Analysis of Behavior*, **30**, 243-253.
- Dunham, P. J., & Grantmyre, J. (1982). Changes in a multiple-response repertoire during response-contingent punishment and response restriction: Sequential relationships. *Journal of the Experimental Analysis of Behavior*, **37**, 123-133.
- Eisenberger, R., Karpman, M., & Tractner, J. (1967). What is the necessary and sufficient condition for reinforcement in the contingency situation? *Journal of Experimental Psychology*, **74**, 342-350.
- Knapp, T. J. (1976). The Premack Principle in human experimental and applied settings. *Behavior Research and Therapy*, **14**, 133-147.
- Lea, S. E. G. (1983). The analysis of need. In R. L. Mellgren (Ed.), *Animal cognition and behavior* (pp. 31-63). Amsterdam: North-Holland.
- Luce, R. D. (1959). *Individual choice behavior: A theoretical analysis*. New York: Wiley.
- Premack, D. (1965). Reinforcement theory. In D. Levine (Ed.), *Nebraska Symposium on Motivation* (Vol. 13, pp. 123-180). Lincoln: University of Nebraska Press.
- Rachlin, H. (1980). Economics and behavioral psychology. In J. E. R. Staddon (Ed.), *Limits to action: The allocation of individual behavior* (pp. 205-236). New York: Academic Press.
- Rachlin, H., & Burkhard, B. (1978). The temporal triangle: Response substitution in instrumental conditioning. *Psychological Review*, **85**, 22-47.
- Staddon, J. E. R. (1979). Operant behavior as adaptation to constraint. *Journal of Experimental Psychology: General*, **108**, 48-67.
- Staddon, J. E. R. (1980). Optimality analyses of operant behavior and their relation to optimal foraging. In J. E. R. Staddon (Ed.), *Limits to action: The allocation of individual behavior* (pp. 101-141). New York: Academic Press.
- Timberlake, W. (1979). Licking one saccharin solution for access to another in rats: Contingent and noncontingent effects in instrumental performance. *Animal Learning & Behavior*, **7**, 277-288.
- Timberlake, W., & Allison, J. (1974). Response deprivation: An empirical approach to instrumental performance. *Psychological Review*, **81**, 146-164.

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