

Behavioral contrast in a second-order multiple schedule of reinforcement*

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Three pigeons were maintained on a two-component multiple schedule of reinforcement, each component of which was a two-component multiple schedule. Behavioral contrast was produced when (1) one of two VI 5-min components, (2) one of two VI 1-min components, or (3) one VI 5-min and one VI 1-min component were changed to extinction. The magnitude of the behavioral contrast was the same in all three cases. Some generalization of extinction and contrast was observed. The data are interpreted as favoring an account of behavioral contrast which is based on emotional processes.

A multiple schedule of reinforcement (*mult*) is one "in which reinforcement is programmed by two or more schedules alternating usually at random. Each schedule is accompanied by a different stimulus, which is present as long as the schedule is in force [Ferster & Skinner, 1957]." A well studied *mult* is *mult* VI VI, a two-component *mult* each component of which is a variable-interval schedule, i.e., a schedule such that responses are reinforced after intervals of time which vary about some specified mean value. If one component of a *mult* VI VI schedule is changed to EXT (extinction, or the nonreinforcement of all responses), the rate of responding during EXT declines and may reach zero, and the rate of responding during the unchanged VI component may increase. This increased rate of responding in the unchanged component is called (positive) behavioral contrast (Reynolds, 1961). Two-component *mults* have been extensively studied, especially with regard to interactions between the components (Reynolds, 1961; Terrace, 1972).

"A second-order schedule (of reinforcement) is one in which the behavior specified by a schedule contingency is treated as a unitary response that is itself reinforced according to some schedule of primary reinforcement [Kelleher, 1966]." An example of a second-order schedule is the procedure in which one unconditioned reinforcer is presented after the completion of three successive VI schedules. In Kelleher's terminology, this is called FR 3 (VI). If each successive VI schedule is correlated with a different exteroceptive stimulus, the schedule is *chain* VI VI VI, according to Ferster and Skinner (1957). A second-order multiple schedule could be composed of two or more components alternating, usually in random succession, each of which is two or more simple schedules of reinforcement. For example, Schnaitter and Winokur (1973) studied a schedule which may be termed *mult* (*chain* VI VI) (*chain* VI VI). "That is, each component of a two-component multiple

schedule was itself a two-link chain schedule. The components of the multiple schedule were presented in random order, but each of the chain schedules was presented in a fixed order [Schnaitter & Winokur, 1973]." Few investigations of second-order multiple schedules have been reported; most of the published literature on second-order schedules deals with investigations of second-order chain schedules (Kelleher, 1966; Marr, 1969). Because of the importance of the analysis of second-order multiple schedules for the interpretation of daily life (Skinner, 1973), an investigation of a second-order multiple schedule, the components of which were themselves multiple schedules, was carried out and is reported here.

METHOD

Subjects

Three auto-sexing King pigeons, which had previously been obtained from the Palmetto Pigeon Plant, Sumter, South Carolina, and had been autoshaped to keypeck, were the Ss. The birds were maintained at 80% of their free-feeding weights by supplemental feedings of Purina Pigeon Checkers at the end of each daily experimental session. Water and grit were always available in the birds' home cages.

Apparatus

The experimental space consisted of a BRS-Foringer pigeon chamber similar to that described by Ferster and Skinner (1957). White noise and the noise of a ventilating fan, which was mounted on the plywood shell enclosing the experimental space, were present in the chamber at a level of 80 dB. The white noise was omitted during presentations of sine wave tone signals which were generated by a Hewlett-Packard audio oscillator. Electromagnetic recording and programming equipment was located in an adjacent sound-shielded room. Reinforcers were 3-sec accesses to Purina Pigeon Checkers.

Procedure

Each daily experimental session had a duration of 88 min. The experiment was composed of six phases. Table 1 summarizes the experimental procedures used, and they are described as follows.

Phase 1 (Baseline). All birds were trained to respond on a second-order multiple schedule. *mult* (*mult* VI 1-min VI 1-min) (*mult* VI 5-min VI 5-min). Each experimental session began with Component 1, the first VI 1-min schedule, and then continued to Components 2, 3, and 4, the second VI 1-min schedule, and

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Table 1
Summary of Experimental Schedules

Component	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
1	VI 1	VI 1	VI 1	VI 1	VI 1	VI 1
2	VI 1	EXT	VI 1	VI 1	VI 1	EXT
3	VI 5	VI 5	VI 5	VI 5	VI 5	VI 5
4	VI 5	VI 5	VI 5	EXT	VI 5	EXT

the first and second VI 5-min schedules, respectively, ad seriatum. Each component schedule had a duration of 22 min. A 1,200-Hz tone was present during Components 1 and 2, while a 600-Hz tone was present during Components 3 and 4. The visual stimulus accompanying Component 1 was a white horizontal bar transprojected on the darkened key (SD_1^D). The discriminative stimulus for Component 2 was a white triangle transprojected on the dark key (SD_2^D). SD_3^D , a white circle, and SD_4^D , a white vertical bar, accompanied Components 3 and 4, respectively, and were transprojected in the same manner. Phase 1 had a duration of 21 days, and comprised the baseline for the experiment. It was immediately succeeded by the following five phases, each having a duration of 10 days.

Phase 2 (Component 1 Contrast). The schedule in effect was the same as that of Phase 1, except that Component 2 was changed from a VI 1-min schedule of reinforcement to EXT. That is, reinforcement was never delivered in the presence of SD_2^D .

Phase 3 (Baseline). The birds were returned to the baseline schedule of Phase 1.

Phase 4 (Component 3 Contrast). The schedule was the same as that during the baseline phases except that an EXT schedule accompanied presentations of SD_3^D , i.e., reinforcement was never delivered in Component 4.

Phase 5 (Baseline). All birds were returned to the baseline schedule of Phases 1 and 3.

Phase 6 (Components 1 and 3 Contrast). An EXT schedule was programmed for Components 2 and 4, i.e., no reinforcers were delivered in the presence of SD_2^D and SD_4^D .

RESULTS AND DISCUSSION

Table 2 depicts each bird's mean response rate for each component computed from all sessions of each phase of the experiment except as follows. The rates shown for Phase 1 were taken from data from the last four sessions of Phase 1. The rates shown for Phase 6 are based on data from only 9 days of Phase 6. An apparatus failure caused the loss of 1 day's data from Phase 6. Table 3 displays the relative rates of responding in each component between successive odd- and even-numbered phases of the experiment.

Examination of Table 2 indicates that during the baseline phases of the experiment (Phases 1, 3, and 5),

all birds responded more rapidly during Components 1 and 2 (VI 1-min schedules) than during Components 3 and 4 (VI 5-min schedules). This indicates a differential effect of the VI 1-min and VI 5-min schedules, but does not imply that responding was under the control of the correlated auditory stimuli. It may be noted that for Bird 51, rates in the two VI 1-min components (1 and 2) and in the two VI 5-min components (3 and 4) were substantially the same during Phases 1, 3, and 5. For Bird 52, rates of pecking in the VI 1-min components (1 and 2) and rates in the VI 5-min components (3 and 4) were similar only during Phase 1; rates in Components 3 and 4 were close together during Phase 5 also. Bird 53 showed similar rates of responding in the VI 1-min components (1 and 2) of Phase 1 and in the VI 5-min components (3 and 4) of Phase 1, and in Components 3 and 4 during Phase 5. This failure to obtain essentially equal rates of responding in the two VI 1-min schedules, and in the two VI 5-min schedules, by two of the birds is puzzling and without explanation at this time.

Examination of Table 3 indicates that the imposition of EXT schedules during Phases 2, 4, and 6 produced behavioral contrast for all birds. There appears to be no significant difference in the magnitude of behavioral contrast generated by the procedure of Phase 2 as compared with the procedure of Phase 4, or as compared with the procedure of Phase 6. This is true when the percentage change in rates of responding is computed using the data from the last four baseline sessions of Phases 1, 3, and 5 and the first four extinction sessions of Phases 2, 4, and 6 (the data for this computation are not shown in this report). The average increase in rates of responding during Component 1 in Phase 2 as compared with Phase 1 was 22.7%. The average increase in rates of responding in Component 3 in Phase 4 as compared with Phase 3 was 25.2%. The average increase in rates of responding in both Components 1 and 3 of Phase 6 as compared with Phase 5 was 27.8%. These data

Table 2
Mean Response Rate in Each Component of Each Phase

Phase	Bird 51 Component				Bird 52 Component				Bird 53 Component			
	1	2	3	4	1	2	3	4	1	2	3	4
1	36.69	39.15	25.44	25.59	69.47	65.97	31.31	28.85	65.06	60.18	36.03	43.61
2	45.88	12.62	26.30	25.34	95.12	22.30	38.88	36.54	69.22	19.33	43.53	52.23
3	46.16	44.66	29.56	28.98	103.90	88.03	39.58	54.88	72.75	62.85	34.79	58.46
4	42.64	42.59	41.16	18.35	72.68	97.79	49.66	19.99	78.91	69.69	38.68	29.17
5	45.29	47.99	39.09	34.86	61.49	69.19	42.16	40.55	80.15	61.83	47.60	43.10
6	50.13	32.44	37.60	16.91	89.82	40.55	54.30	14.27	77.95	27.84	52.11	30.73

Table 3
Relative Response Rates

Component	Phase 2/Phase 1				Phase 4/Phase 3				Phase 6/Phase 5			
	1	2	3	4	1	2	3	4	1	2	3	4
Bird 51	1.250	.322	1.033	.990	.922	.953	1.392	.634	1.106	.675	.961	.485
Bird 52	1.369	.338	1.241	1.266	.699	1.110	1.254	.364	1.460	.586	1.287	.351
Bird 53	1.063	.321	1.208	1.197	1.084	1.108	1.111	.498	.972	.450	1.094	.712

are in accord with those of Reynolds (1961) and support his conclusion that the magnitude of behavioral contrast shown is unrelated to the amount of reduction of the rate of responding in a multiple schedule.

Further examination of Table 3 indicates that both behavioral contrast effects and extinction effects had a tendency to generalize to other components of the multiple schedule. These generalized contrast and extinction effects, which might be termed induction (Reynolds, 1961), did not seem to follow any particular pattern. This generalization of contrast and extinction effects, and the lack of equality of response rates during the VI 1-min and during the VI 5-min components during the baseline phases, suggest that an imperfect degree of stimulus control was established over responding in the four components of the second-order multiple schedule.

Currently two types of theories are being advanced to account for the generation of behavioral contrast. Terrace (1972) has argued that behavioral contrast is generated by emotionality which itself is generated by an individual being required to learn to make a response which is antagonistic to a response which he has made before. In extinction, a pigeon which has previously responded to a stimulus has to make a response antagonistic to pecking. This produces emotionality which invigorates responding to stimuli uncorrelated with extinction. The data of this experiment are in accord with Terrace's account.

Bloomfield (1969) has suggested that when a pigeon receives a less preferred situation in one component of a multiple schedule, his rate of responding will increase in the other components. We may assume that the pigeon's preference hierarchy starts, in this case, with VI 1-min

schedules, then decreases to VI 5-min schedules, and finally decreases to EXT schedules. Thus, switching a component of the second-order multiple schedule from VI 1-min to EXT should be a greater change in preference than switching a component from a VI 5-min schedule to EXT. Presumably the amount of contrast produced would be related to the amount of preference change involved in changes of schedules of reinforcement. The data reported here do not seem to conform to Bloomfield's account because the amount of behavioral contrast shown by the birds did not seem to be related to the amount of change in the preference hierarchy related to the changes in component schedules.

REFERENCES

- Bloomfield, T. M. Behavioral contrast and the peak shift. In R. M. Gilbert and N. S. Sutherland (Eds.), *Animal discrimination learning*. New York: Academic Press, 1969. Pp. 215-241.
- Ferster, C. B., & Skinner, B. F. *Schedules of reinforcement*. New York: Appleton-Century-Crofts, 1957.
- Kelleher, R. T. Chaining and conditioned reinforcement. In W. K. Honig (Ed.), *Operant behavior: Areas of research and application*. New York: Appleton-Century-Crofts, 1966. Pp. 160-212.
- Marr, M. J. Second-order schedules. In D. P. Hendrey (Ed.), *Conditioned reinforcement*. Homewood, Ill: Dorsey Press, 1969. Pp. 37-60.
- Reynolds, G. S. Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, 1961, 4, 57-71.
- Schnaitter, R., & Winokur, S. Some interactions in a higher order multiple schedule of reinforcement. *Bulletin of the Psychonomic Society*, 1973, 2, 410-412.
- Skinner, B. F. Answers for my critics. In H. Wheeler (Ed.), *Beyond the punitive society*. San Francisco: Freeman, 1973. Pp. 256-266.
- Terrace, H. S. By-products of discrimination learning. In G. H. Bower (Ed.), *The psychology of learning and motivation*. Vol. V. New York: Academic Press, 1972. Pp. 195-265.

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