

FREEDOM AND KNOWLEDGE: AN EXPERIMENTAL ANALYSIS OF PREFERENCE IN PIGEONS¹

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Relative responding in initial links of concurrent-chain schedules showed that pigeons preferred free to forced choices and informative to uninformative stimuli. Variable-interval initial links on two lower keys (white) of a six-key chamber produced terminal links on either two upper-left keys (blue and/or amber) or two upper-right keys (green and/or red). Terminal links in which pecks on either of two lit keys produced fixed-interval reinforcement (free choice) were preferred to links with only one lit fixed-interval key available (forced choice). Terminal links with different key colors correlated with concurrent fixed-interval reinforcement and extinction (informative stimuli) were preferred to links with these schedules operating on same-color keys (uninformative stimuli). Scheduling extinction for one of the two free-choice keys assessed preference for two lit keys over one lit key, but confounded number with whether stimuli were informative. Fixed-interval reinforcement for both keys in each terminal link, but with different-color keys in one link and same-color keys in the other, showed that preference for informative stimuli did not depend on stimulus variety. Preferences were independent of relative responses per reinforcement and other properties of terminal-link performance.

Whatever else is involved in the concept of freedom, it at least involves the availability of alternatives. An organism with no opportunity to choose among alternatives is not called free. In the psychological vocabulary, the availability of alternatives has long been the basis for distinguishing among free choices and forced choices. The assertion that ". . . 'free will' is the awareness of alternative choices" (Koestler, 1964, p. 633) is implicit in contemporary discussions of freedom (*e.g.*, Toffler, 1970) and has acquired the status of dictionary defini-

tion: "free-dom . . . The capacity to exercise choice; free will" (*American Heritage*, 1969). Although these usages mention free will, they actually leave open the question of whether organisms can choose freely or must choose in predetermined ways.

If an organism is free only when alternatives are available, it can be further said to value freedom only if it prefers the availability of alternatives to the unavailability of alternatives (*cf.* Brehm, 1966; Brigham and Sherman, 1973; Voss and Homzie, 1970). The role of freedom is controversial (*e.g.*, Skinner, 1971), and it is not clear whether, in human behavior, the availability of alternatives is preferred. It has even been suggested that humans avoid freedom more readily than seek it (*e.g.*, Fromm, 1941). But human behavior is highly determined by social and cultural contingencies; for this reason, studying preference for alternatives in a nonhuman organism may simplify the task of demonstrating it and elucidating its behavioral or biological basis.

The present studies analyzed preference for the availability of alternatives in pigeons. The availability of an alternative necessarily involves the presentation of a stimulus correlated with that alternative, and the availability of several alternatives implies the presentation of several stimuli. (This usage distinguishes al-

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ternatives, the various stimulus-correlated contingencies presented to an organism, from choices, the organism's mutually exclusive responses to those alternatives.) Further, because stimuli may be differentially correlated with alternatives, they may vary in informative function as well as in number or variety. Thus, the research must inevitably turn also to analyses of variables often confounded with the availability of alternatives: preference for stimulus number or variety (*e.g.*, Berlyne, 1966), and preference for informative over uninformative stimuli (*e.g.*, Egger and Miller, 1962). In the present research, experiments on pigeons' preference for free choice over forced choice led, through experiments on stimulus number, to experiments on preference for informative stimuli. The availability of alternatives is of little significance to an organism that is not informed about the potential consequences of those alternatives, and therefore the study of free choice must generate an analysis of informative stimuli. Because freedom and knowledge are inextricably related in this behavioral sense, it is appropriate that they are examined together in the present experiments.

GENERAL METHOD

Subjects

Three adult male White Carneaux pigeons were maintained at about 80% of free-feeding weights. Pigeon 53 had served in an operant laboratory course and in research on concurrent interval schedules, Pigeon 211 in research on percentage-reinforcement schedules, and Pigeon 280 in an autoshaping procedure. All three pigeons then served in a five-key chamber for about 200 pilot sessions. In Session 1 of the present study, Pigeons 53 and 211 were about 3 yr old, and Pigeon 280 was about 2 yr old.

Apparatus

Daily sessions were conducted in a six-key chamber, the panel of which is illustrated in Figure 1 (modified from the four-key chamber in Catania and Dobson, 1972: the upper-right key was added for pilot research and, later, the sixth key for left-right symmetry of procedures). Of the six translucent Gerbrands keys, the two lower keys could be lit white, the two upper-left keys blue or amber, and the two

upper-right keys green or red, by 6-W Christmas-tree lamps. The keys were matched to operate at minimum forces of 0.14 N, and each peck on a lit key produced a feedback click from a relay behind the panel. Dark-key pecks had no scheduled consequences. During 3-sec deliveries of grain, the standard Gerbrands feeder was illuminated and all keylights were off. No houselight was used. A speaker and a ventilating fan provided masking noise. Scheduling and recording were arranged by standard electromechanical equipment in an adjoining room.

Procedure

Each procedure used concurrent-chain schedules (Autor, 1960; Herrnstein, 1964): according to concurrent initial-link schedules, responses produced separately operating terminal links. In initial links of the example in Figure 2 (top), the two lower keys were lit white and the other keys were dark. According to independent variable-interval (VI) schedules, pecks on these keys produced their respective terminal links, shown in brackets. In left terminal links, fixed-interval (FI) reinforcement was available on either of two keys, lit blue and amber or amber and blue; at the end of the FI, a peck on either lit key produced food, and initial links were then re-instated.

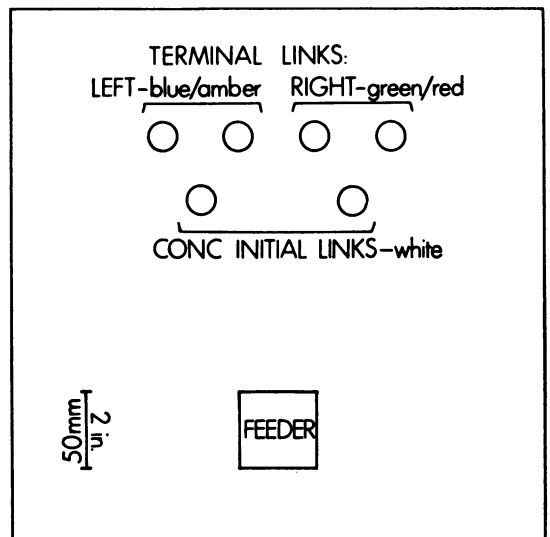


Fig. 1. The six-key experimental panel. Concurrent (CONC) initial links operated on the lower keys, lit white. Terminal links operated either on the upper left keys, lit blue and/or amber, or on the upper right keys, lit green and/or red. Details in text.

In right terminal links, FI reinforcement was available on only one key of the two upper-right keys, lit green; at the end of the FI, a peck on the green key produced food, and initial links were then re-instated. Thus, initial-link pecks on the bottom-left key produced terminal links with two FI keys available (free choice), whereas initial-link pecks on the bottom-right key produced terminal links with only one FI key available (forced choice). Relative rates of pecking in the respective initial links measure preference for free-choice and forced-choice terminal links.

Independent concurrent VI 30-sec VI 30-sec schedules in initial links were each made up of 20 intervals constructed according to Catania and Reynolds (1968, Appendix II), but the order of intervals for the left key was the reverse of that for the right. Intervals were timed from the end of reinforcement in a schedule's preceding terminal link; neither schedule operated during terminal links or reinforcement. Daily sessions ended after 15 min of initial links (a maximum of about 30 left and 30 right terminal links). Through Session

609, any initial-link peck was eligible to produce scheduled terminal links (changeover ratio or COR 1); thereafter, the first peck after a switch from the other initial-link key was not eligible (COR 2).

In terminal links, a 20-sec FI schedule operated for a single lit key with the other key dark, for one of two lit keys with extinction (EXT) scheduled for the other lit key, or for each of two lit keys. With two lit keys, the first peck after 20 sec was reinforced without regard to the prior sequence of pecks on the two keys during the 20-sec interval. All terminal links ended after a single FI reinforcement; thus, a peck on only one key could be reinforced within any single terminal link. In a given terminal link, the stimuli and/or schedules assigned to the two keys alternated irregularly (*e.g.*, in Figure 2, blue-amber or amber-blue in left terminal links, and green-left or green-right in right terminal links).

Table 1 outlines the sequence of procedures, with sessions numbered consecutively from the first session with the six-key chamber. Pilot Sessions 1 through 144 examined schedule parameters and other procedural details. Sessions 145 through 244 examined preference for free choice over forced choice: two FI keys were available in one terminal link, and only a single FI key in the other. Sessions 245 through 250 attempted to redetermine baseline data, but included an apparatus failure; baseline data were therefore taken from Sessions 251 through 257 of the next procedure. Sessions 251 through 286 examined preference for two lit keys over one lit key. This asymmetrical procedure varied one terminal link while the other terminal link was held constant. Sessions 287 through 395 were additional pilot sessions that included several sessions in which one or more keys intermittently failed to operate. Sessions 396 through 469 examined preference for informative over uninformative stimuli; FI and EXT schedules were each correlated with a different stimulus in one terminal link, while they were both correlated with the same stimulus in the other terminal link. Sessions 470 through 623 were predominantly devoted to examining the sensitivity of the concurrent-chain schedules to reinforcement variables. Procedures included concurrent VI EXT and EXT VI schedules in initial links, and other studies of the independence of the concurrent initial-link responses. Sessions 624 through 678

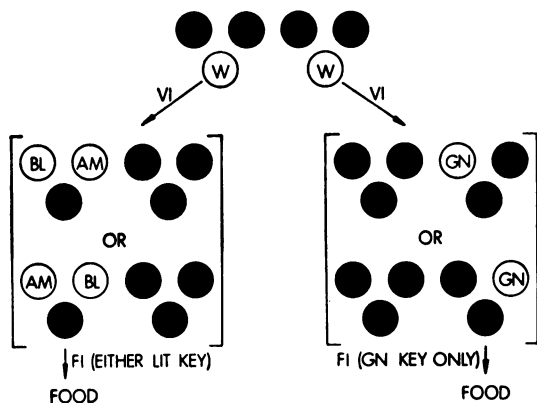


Fig. 2. Example of a concurrent chain procedure. During initial links (top), the lower two keys were lit white (W). According to independent concurrent variable-interval (VI) schedules, pecks on these keys produced terminal links. In left terminal links (left brackets), the two upper-left keys were lit either blue (BL) and amber (AM) or amber and blue; over successive terminal links, the positions of the two colors changed according to an irregular sequence. At the end of a fixed interval (FI), a peck on either lit key produced food, and initial links were then re-instated. In right terminal links (right brackets), one of the two upper-right keys was lit green (GN); over successive terminal links, the position of the lit key changed according to an irregular sequence. At the end of a fixed interval (FI), a peck on the lit key produced food, and initial links were then re-instated.

Table 1
Summary of Procedures

<i>Procedure</i>	<i>Terminal link X</i>	<i>Terminal link Y</i>	<i>COR</i>	<i>Sessions</i>
IA. Free-choice (X) <i>versus</i> forced-choice (Y).	Two different-color keys, FI FI.	One key, FI (color or position forced).	1	145-244
IIA. Two stimuli <i>versus</i> one stimulus (both Y): asymmetrical.	Two different-color keys, FI FI.	One key, FI, or two different-color keys, FI EXT.	1	251-286
III. Informative stimuli (X) <i>versus</i> uninformative stimuli (Y).	Two keys, different FI and EXT stimuli.	Two keys, same-color FI and EXT stimuli.	1	396-469
IB. Free-choice (X) <i>versus</i> forced-choice (Y).	Two different-color keys, FI FI.	One key, FI (color forced only).	2	624-678
IV. Stimulus variety (X) <i>versus</i> no stimulus variety (Y).	Two different-color keys, FI FI.	Two same-color keys, FI FI.	2	679-699
IIB. Two stimuli (X) <i>versus</i> one stimulus (Y): symmetrical.	Two keys, different FI and EXT stimuli.	One key, FI.	2	700-714, 725-729

FI = fixed interval; EXT = extinction; COR = changeover ratio.

partially replicated the earlier study of free-choice preference. Sessions 679 through 704 examined preference for stimulus variety. Of these, Sessions 700 through 704 also served as a baseline for a further study of preference for two stimuli over one stimulus, in Sessions 705 through 714. After sessions devoted to a peripherally related procedure, Sessions 725 through 729 provided some additional baseline data.

Through Session 699, sessions were conducted daily. Because of time limitations (*cf.* Footnote 1), data were obtained in morning sessions of standard duration and then again in afternoon sessions beginning with Session 700. Pigeon 211 remained at about 80% of free-feeding weight, Pigeon 53 began consistently to exceed this weight at about Session 715 and reached 85% by the final session, and Pigeon 280 gained weight rapidly and completed the experiment at better than 90% of free-feeding weight. Thus, over the last 20 or 25 sessions, preferences for Pigeon 280, and perhaps for Pigeon 53, may not be comparable to those in earlier sessions.

EXPERIMENT I.

FREE CHOICE *versus* FORCED CHOICE

In an experiment on the value of choice, Voss and Homzie (1970) measured food-de-

prived rats' preferences for two paths leading to a sucrose solution. One path consisted of a single predetermined route; the other allowed the rat a choice between two subpaths. Possible left and right combinations of paths and subpaths were counterbalanced among four groups. On the average, rats chose the path with alternative subpaths 59% of the time, and this direction of preference was shown by 14 of 15 rats. The availability of alternatives was not separable from the different stimulus properties of routes with or without subpaths, nor was the possibility of preference for exploration or for variability excluded (Dashiell, 1925; Krechevsky, 1937). Nevertheless, the findings are consistent with the interpretation that organisms prefer the availability of alternatives or, given the opportunity, will "choose to choose". The present experiment examined the preference for alternatives in pigeons. Pecks on one of two keys occasionally produced a single route to a food reinforcer; pecks on the other occasionally produced a choice between two routes to the same reinforcer.

METHOD

Figure 3 outlines the terminal links produced by the concurrent VI VI initial-link schedules. Each terminal link irregularly alternated between two key arrangements, shown

above and below the short horizontal lines. In the baseline procedure (no choice), a single key operated in each terminal link: either amber in left terminal links and red in right, or blue in left and green in right. Preliminary sessions showed no consistent color preferences, and the two baseline conditions were therefore pooled in data presentation. A later baseline determination arranged free choice in both terminal links (Figure 5, Sessions 251 to 257).

The first free-choice *versus* forced-choice sequence included both forced choice of color and forced choice of position in one of the two terminal links; the second sequence included only forced choice of color. Conditions

with free choice in left terminal links alternated with those with free choice in right terminal links. Each condition lasted seven to 10 consecutive daily sessions, except for an extended observation with forced choice of green (Sessions 656 to 673) and the last observation with forced choice of blue (Sessions 674 to 678). The latter condition was maintained for only five sessions, after detailed analysis showed that averages over the last three of five sessions differed only slightly from those over the last three of six to 10 sessions.

The several forced-choice conditions followed from the assumption that any observed preference for free-choice terminal links would be difficult to assess, and perhaps uninterest-

CONDITION	TERMINAL LINKS		SESSIONS	TERMINAL LINKS		SESSIONS
	LEFT	RIGHT		LEFT	RIGHT	
BASELINE— NO CHOICE	(A) ●	(R) ●	145-156 631-640	(B) ●	(G) ●	157-163 624-630
	● (A)	● (R)		● (B)	● (G)	
FORCED CHOICE— COLOR	(A) (B)	(G) ●	164-170 656-673	(A) ●	(G) (R)	171-177 649-655
	(B) (A)	● (G)		● (A)	(R) (G)	
	(A) (B)	(R) ●	178-187 641-648	(B) ●	(G) (R)	188-198 238-244
	(B) (A)	● (R)		● (B)	(R) (G)	
FORCED CHOICE— POSITION	(A) (B)	(G) ●	215-221 231-237	(A) ●	(G) (R)	208-214
	(B) (A)	(R) ●		(B) ●	(R) (G)	
	(A) (B)	● (G)	199-207	● (A)	(G) (R)	222-230
	(B) (A)	● (R)		● (B)	(R) (G)	

Fig. 3. Summary of free-choice *versus* forced-choice conditions. Terminal links only are shown, for Sessions 145 to 244 (COR 1) and Sessions 624 to 678 (COR 2). In baseline conditions (top row), each terminal link included only a single key: amber (A) in the left terminal link and red (R) in the right, or blue (B) in the left and green (G) in the right. Over successive terminal links, the positions of the colors alternated irregularly; the two possible key arrangements are shown above and below the short horizontal lines. The remaining conditions provided free choice of two keys in one terminal link and forced choice of a single key in the other terminal link. The left column shows procedures with two keys, one amber and one blue, in left terminal links (free choice); right terminal links included either a single color available in one of two irregularly alternating positions (forced choice - color) or a single position available in one of two irregularly alternating colors (forced choice - position). The right column shows analogous procedures with free choice in right terminal links (one green and the other red) and forced choices of either color or position in left terminal links.

ing, if it were small relative to color or position preferences (a particular terminal-link key might be preferred, for example, if it favored observation of and movement toward the feeder). Preference for free choice in each terminal link was therefore examined with choices forced to each possible color and position in the other terminal link.

RESULTS

Baseline data and preferences are summarized for each pigeon in Figure 4. Successive conditions are shown from top to bottom of the figure. Each point represents initial-link responding (left initial-link responses divided by left plus right initial-link responses); apex-left triangles represent conditions with free choice in left terminal links and apex-right triangles those with free choice in right terminal links. Displacements to the left or right correspond to shifts of preference toward left or right terminal links.

For Pigeon 53 (left), preference first shifted to the left when free choice was introduced in the left terminal link (BL to C_g). When free choice was then moved to the right (C_g to C_a), preference shifted to the right. Each subsequent change in the locus of free-choice was accompanied by a corresponding shift in preference. Similar shifts in preference were obtained in the second sequence (bottom connected points), after more than 400 intervening sessions of other procedures. The data for Pigeon 211 (middle) and Pigeon 280 (right), though different in magnitude, were comparable in direction. A change in free-choice from right to left for Pigeon 280 (R_{ll} to R_{rr}) was the only instance in which a corresponding shift in preference was not obtained (the relative rates, equal to two decimal places, did not constitute a reversal). Thus, in 44 of the 45 schedule changes in Figure 4, relative rates shifted in accordance with preference for free-choice terminal links. On the average, preferences for free-choice terminal links were larger with forced choice of color (C) than with forced choice of position (P) in the other terminal link.

Changes in preference were largest for Pigeon 211 and smallest for Pigeon 280. The individual differences remained consistent throughout both sequences of procedures. Relative rates also differed under baseline conditions, when equivalent conditions operated

in both terminal links. Pigeon 53's baseline relative rate remained in the region of 0.4 through both sequences. For Pigeons 211 and 280, the baseline relative rate moved from

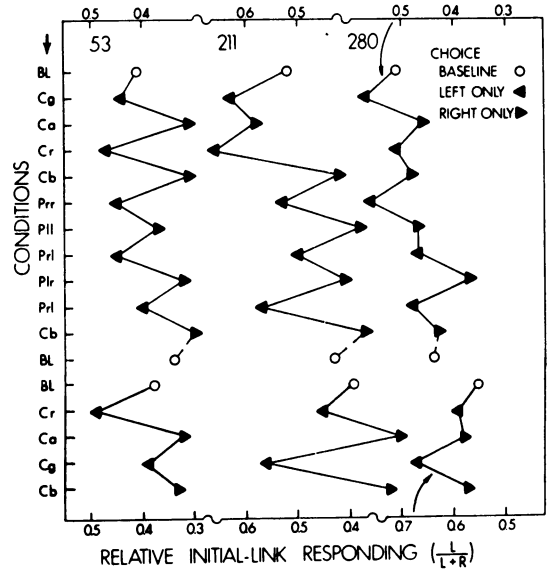


Fig. 4. Relative initial-link responding (left initial-link rate divided by sum of left and right initial-link rates) over successive free-choice versus forced-choice conditions, for three pigeons. Conditions, shown from top to bottom in the order in which they were studied, include baseline (BL), free choice versus forced choice of color (C), and free choice versus forced choice of position (P). With color forced, the subscripts g, a, r, or b respectively identify green, amber, red, or blue forced choices. With position forced, the subscripts l or r respectively identify forced choice in left or right terminal links and to left or right keys of a given terminal link, in that order (e.g., P_{lr} indicates left terminal link, right-key forced choice, corresponding to the procedure of Sessions 222 to 230, Figure 3). Free-choice versus forced-choice data with free choice in the left terminal link are shown by apex-left triangles; those with free choice in the right terminal link are shown by apex-right triangles. The x-axis has been scaled so that displacements to the left or right respectively indicate an increase or a decrease in left terminal-link preference (relative responding in left initial link). Thus, a displacement in the direction to which the apex of a triangle points implies a shift in preference toward a free-choice terminal link. Different scales are provided for each pigeon; in addition, separate upper and lower scales are provided for the two successive sets of data for Pigeon 280. Each point represents the arithmetic mean over the last three sessions of a given condition. The upper data connected by solid lines represent Sessions 145 to 244; the lower represent Sessions 624 to 678. Baseline data at the beginning of each sequence were pooled across conditions with different terminal-link colors (Figure 3, top row); those connected to the first sequence by dashed lines were obtained from Sessions 251 to 257 (cf. Figure 5).

about 0.5 to about 0.4 during the first sequence. This baseline relative rate apparently shifted abruptly for Pigeon 211 (C_r to C_b), but gradually for Pigeon 280. In the second sequence, Pigeon 211's baseline relative rate was again about 0.4, but Pigeon 280's had shifted almost to 0.6 (note different top and bottom scales for this pigeon).

DISCUSSION

Each pigeon reliably preferred terminal links providing two alternative routes to reinforcement (free choice) to terminal links providing only a single route to reinforcement (forced choice). Because the concurrent VI VI initial-link schedules made both terminal links available equally often, and because the separate terminal-links included equal FI schedules, the preferences are not reducible to differences in reinforcement frequency or immediacy. Responses per reinforcement and other properties of terminal-link performance, discussed later, also seem inadequate to account for the observed preferences. But another difficulty remains. In each free-choice terminal link, two keys were lit; in each forced-choice terminal link, only a single key was lit. Even though both types of terminal links made reinforcement available equally often and according to the same schedule, preference might have depended on the presentation of two lit keys, rather than a single lit key.

EXPERIMENT II.

STIMULUS NUMBER:

TWO LIT KEYS *versus* ONE LIT KEY

Visual stimuli can serve as reinforcers, and some have a greater reinforcing effect than others (*e.g.*, Berlyne, 1966; Kish, 1966). For example, when each of two concurrent VI VI schedules made a different visual stimulus available to humans, higher response rates were maintained by the more complex visual stimulus (Berlyne, 1972). The presentation of two lights in free-choice terminal links and only one light in forced-choice terminal links involved at least a difference in stimulus quantity, if not also a difference in complexity.

Preference for number of stimuli was examined by introducing extinction (EXT) in the presence of one of the two colors of each terminal link. The number of lit keys could then

be varied, without altering terminal-link FI reinforcement, by presenting or removing this stimulus. The first procedure, which presented or removed an EXT stimulus in the right terminal link while holding the left terminal link constant, asymmetrically compared preference of two lights *versus* two lights with preference of two lights *versus* one light. The second procedure, which switched the presence or absence of an EXT stimulus from one terminal link to the other, symmetrically compared preference of one light *versus* two lights with preference of two lights *versus* one light.

METHOD

For convenience of presentation, the sequence of conditions in Figure 5 shows only one of the two alternative positions of the stimuli and their correlated schedules in each terminal link. In the asymmetrical first procedure (Sessions 251 to 286), each condition lasted six to eight sessions; in the symmetrical second procedure (Sessions 700 to 729), each condition lasted five sessions. Sessions unrelated to Experiment II intervened between the last condition and baseline redetermination (Sessions 714 to 724).

The first procedure determined baseline preference with free choice in both terminal links. The schedule for the red key of right terminal links was then changed from FI to EXT, so that two routes to food were available in left terminal links (blue and amber), but only a single route in right terminal links (green). Whether red was present or absent, therefore, subsequent conditions included free choice in left terminal links and forced choice in right terminal links. One condition, however, presented two lit keys in both terminal links (EXT, R), whereas the other presented two lit keys in left terminal links and only a single lit key in right terminal links (NO R: note that this equals forced-choice-of-green in Figure 3). Each condition was examined twice.

The second procedure changed the schedules for both the amber key of left terminal links and the red key of right terminal links from FI to EXT. Both terminal links therefore made available only a single route to food (blue in left and green in right). The initial baseline condition with two lit keys in each terminal link was followed by one lit key in the left terminal link and two in the right, and then two lit keys in the left and one in

CONDITIONS	TERMINAL LINKS				SESSIONS
	LEFT		RIGHT		
BASILINE 1 NO EXT	(B) FI	(A) FI	(G) FI	(R) FI	251-257
EXT, R	(B) FI	(A) FI	(G) FI	(R) EXT	258-265 273-280
NO R	(B) FI	(A) FI	(G) FI	● EXT	266-272 281-286
BASILINE 2 EXT, A & R	(B) FI	(A) EXT	(G) FI	(R) EXT	700-704
EXT, R; NO A	(B) FI	● EXT	(G) FI	(R) EXT	705-709
EXT, A; NO R	(B) FI	(A) EXT	(G) FI	● EXT	710-714
BASILINE 3 NO A, NO R	(B) FI	● EXT	(G) FI	● EXT	725-729

Fig. 5. Summary of one-lit-key *versus* two-lit-keys conditions. Sessions 251 to 286 (COR 1) asymmetrically examined the effect of number of lit keys, by holding left terminal links constant and varying right terminal links: in right terminal links, conditions differed only by whether two keys were lit or one key was lit. Sessions 700 to 729 (COR 2) symmetrically examined the effect of number of lit keys, by reversing conditions in left and right terminal links: one key was lit in one terminal link, and both keys were lit in the other terminal link. Baseline conditions arranged equivalent correlations of key colors with schedules in each terminal link. In each terminal link, only one of two possible positions of key colors and correlated schedules is shown; positions of the key colors and their correlated schedules alternated irregularly over successive terminal links. FI—fixed interval; EXT—extinction. Color abbreviations as in Figure 3.

the right. A final baseline condition provided only one lit key in each terminal link. Throughout the second procedure, two sessions were conducted daily, with consequent increases in the body weights of Pigeon 280 and, to a lesser extent, Pigeon 53 (*cf.* General Method).

RESULTS

As in Figure 4, Figure 6 displays successive conditions for each pigeon from top to bottom; displacements to left or right correspond in direction to changes in preference. For the asymmetrical procedure, baseline preference is shown by unfilled circles, preference with two lit keys in both terminal links by filled

squares, and preference with two lit keys in left terminal links and one in right by apex-left filled triangles. For the symmetrical procedure, baseline preferences are shown by filled circles, and preferences with two lit keys *versus* one lit key are shown by unfilled triangles pointing to the side on which the terminal link included two lit keys.

For Pigeon 53 in the asymmetrical procedure, preference shifted somewhat to the left, in the direction of free-choice terminal links, from a baseline level of about 0.35. Preference was not substantially affected by whether the left terminal link included two lit keys or one lit key. Number of keys was not an important determinant of this pigeon's preference.

For Pigeons 211 and 280, the change from two lit keys to one lit key substantially affected preference. Both pigeons began at baseline levels between 0.40 and 0.45. Comparable preferences were maintained with two keys in each terminal link after the red-key schedule was changed to EXT (EXT, R), but preference shifted to the left by about 0.1 when the red key was removed (NO R). Both conditions

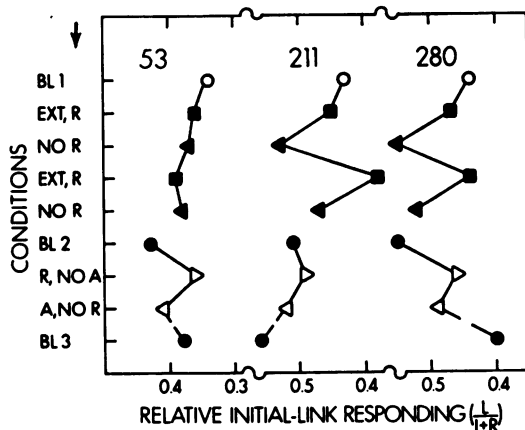


Fig. 6. Relative initial-link responding over successive conditions in the asymmetrical (top data points) and symmetrical (bottom data points) one-lit-key *versus* two-lit-keys procedures. After baseline determination in the asymmetrical procedure (unfilled circles), data obtained with two keys lit in both terminal links (filled squares) were compared with data obtained with two keys lit in left terminal links and only one key lit in right terminal links (apex-left filled triangles). Between baseline determinations in the symmetrical procedure (filled circles), data obtained with two keys lit in right terminal links and one key lit in left terminal links (apex-right unfilled triangles) were compared with data obtained with two keys lit in left terminal links and one key lit in right terminal links (apex-left unfilled triangles). Details as in Figure 4.

included free-choice left terminal links and forced-choice right terminal links, but left preference emerged only when two lit keys were pitted against one lit key.

In the symmetrical procedure, all three pigeons shifted preference from right to left when the terminal link with two lit keys was changed from right to left, but the differences in relative rate did not exceed 0.05. This magnitude of preference was smaller than that for free choice. Initial baseline levels were not well-recovered after the experimental conditions, probably for reasons above (*cf.* General Method).

DISCUSSION

The asymmetrical procedure examined preference for number of lit keys indirectly, by eliminating the number of lit keys as a basis for preference. The results were inconsistent across pigeons. The symmetrical procedure examined this preference more directly, by moving the two lit keys from one terminal link to the other. The preferences for two lit keys in this procedure were small.

Two lit keys provide a choice, albeit a highly determined one (*cf.* Hobson's choice), even if one key is correlated with EXT. The asymmetrical procedure might therefore be interpreted as comparing free-choice-*versus*-free-choice links (EXT, R) with free-choice-*versus*-forced-choice links (NO R). Further, the symmetrical procedure would also follow as an instance of free choice *versus* forced choice, making preference for choice indistinguishable from preference for stimulus number. But if lit keys correlated with EXT are alternatives, then unlit keys correlated with EXT are also alternatives, and procedures substituting lit EXT keys for unlit keys should be equivalent. This was not the case, however. Unlit keys were not functionally equivalent to lit keys, presumably because discrimination between lit and unlit keys was well established by an extensive experimental history (in which upper keys were lit during terminal links, but never during initial links), and because discrimination among lit keys of different colors, with FI reinforcement and EXT in terminal links, followed substantial histories of FI reinforcement in the presence of each color (through Session 257: *cf.* Figure 5).

But distinguishing lit keys from unlit keys implies another potential function of lit keys.

When FI reinforcement and EXT are each scheduled for one of two lit keys, stimuli correlated with these schedules become informative. If a preference exists for informative stimuli, then preference in the first two-lit-keys procedure (EXT, R) may represent a balance between free choice in one terminal link and informative stimuli in the other.

EXPERIMENTS III AND IV. INFORMATIVE *versus* UNINFORMATIVE STIMULI, AND THE CONTRIBUTION OF STIMULUS VARIETY

Studies of the reinforcing value of informative stimuli constitute an extensive and controversial literature (*e.g.*, Bower, McLean, and Meacham, 1966; Egger and Miller, 1962; Golub, 1970; Hendry, 1969). Some studies examine whether stimuli correlated with different conditions of reinforcement will maintain observing responses (*e.g.*, Kelleher, 1958; Wyckoff, 1952). Others examine preferences for the terminal links of concurrent chain schedules when stimuli are differently correlated with time or reliability of reinforcement delivery in these terminal links (*e.g.*, Daniels, 1971; Hursh and Fantino, 1974). Both types of studies have difficulty separating the presentation of different stimuli from the different distributions in time of reinforcers delivered during each stimulus (*e.g.*, Dinsmoor, Brown, and Lawrence, 1972; Jenkins and Boakes, 1973; Mulvaney, Dinsmoor, Jwaideh, and Hughes, 1974).

An advantage of scheduling FI reinforcement on one or both of two terminal-link keys is that stimuli may be varied without affecting the time at which reinforcement becomes available during each stimulus. Informative stimuli can be added to a terminal link without altering the relative frequency of reinforcement in that terminal link. Thus, FI reinforcement and EXT were scheduled for the two keys of each terminal link, but different stimuli were correlated with the two schedules in only one of the two terminal links, so that preferences based on the informative function of the latter stimuli were independent of terminal-link reinforcement variables. Because informative stimuli are necessarily different stimuli, the data on preference for informative over uninformative stimuli were

also supplemented by data on preference for stimulus variety.

METHOD

For convenience of presentation, the sequence of conditions in Figure 7 shows only one of the two alternative positions of the stimuli and/or their correlated schedules in each terminal link. Experiment III (Sessions 396 to 469) examined preference for informative stimuli; each condition lasted eight to 11 sessions, except for the second baseline deter-

mination, which lasted 15 sessions. Experiment IV (Sessions 679 to 704) examined preference for stimulus variety; each condition lasted five sessions.

In Experiment III's baseline condition, an FI schedule operated on only one of the two lit keys in each terminal link; EXT was scheduled on the other key. Because both keys were lit the same color (blue in left terminal links and green in right), the stimuli were not informative with respect to the location of the FI schedule. Informative stimuli were then provided by lighting the EXT key of the left terminal link amber (INFO 1) or by lighting the EXT key of the right terminal link red (INFO 2). Conditions with informative stimuli in one of the two terminal links were irregularly alternated with each other and with the baseline condition.

In informative-stimulus conditions, terminal links with informative stimuli included two keys lit different colors, whereas the other terminal links included two keys lit the same color. Experiment IV examined preference for varied stimuli by manipulating key colors during FI reinforcement for both lit keys of each terminal link, when the stimuli could not have an informative function. Conditions with different-color keys in left terminal links and same-color keys in right (VARIETY 1 and VARIETY 3) alternated with conditions with same-color keys in left terminal links and different-color keys in right (VARIETY 2 and VARIETY 4). A subsequent baseline condition (*cf.* Figure 5, BASELINE 2) provided informative stimuli, and therefore also variety, in both terminal links.

RESULTS

Figure 8 summarizes the results for each pigeon. As in Figures 4 and 6, successive conditions are shown from top to bottom, and displacements to left or right correspond in direction to changes in preference. The upper points show data on preference for informative over uninformative stimuli (Experiment III). Filled circles show baseline determinations with neither informative stimuli nor variety in terminal links, apex-left unfilled triangles represent informative stimuli in left terminal links, and apex-right unfilled triangles represent informative stimuli in right terminal links. The lower points show data on preference for stimulus variety (Experiment

CONDITIONS	TERMINAL LINKS				SESSIONS
	LEFT		RIGHT		
BASELINE 1 NO INFO NO VARIETY	(B) FI	(B) EXT	(G) FI	(G) EXT	396-405 417-431 453-460
INFO 1	(B) FI	(A) EXT	(G) FI	(G) EXT	406-416 442-452
INFO 2	(B) FI	(B) EXT	(G) FI	(R) EXT	432-441 461-469
VARIETY 1	(B) FI	(A) FI	(G) FI	(G) FI	679-683
VARIETY 2	(B) FI	(B) FI	(G) FI	(R) FI	684-689
VARIETY 3	(B) FI	(A) FI	(R) FI	(R) FI	690-694
VARIETY 4	(A) FI	(A) FI	(G) FI	(R) FI	695-699
BASELINE 2 INFO, VARIETY	(B) FI	(A) EXT	(G) FI	(R) EXT	700-704

Fig. 7. Summary of informative-stimulus and variety conditions. In Sessions 396 to 469 (COR 1), fixed-interval (FI) reinforcement was arranged for one key and extinction (EXT) for the other key in each terminal link. In baseline conditions, the two keys of each terminal link were the same color. Different colors were then correlated with FI and EXT either in left terminal links (INFO 1: blue correlated with FI and amber with EXT) or in right terminal links (INFO 2: green correlated with FI and red with EXT). The positions of the schedules alternated irregularly on the two keys over successive presentations of each terminal link. In Sessions 679 to 699 (COR 2), FI reinforcement was arranged for both keys in each terminal link, but two different colors were available either in left terminal links (VARIETY 1 and VARIETY 3) or in right terminal links (VARIETY 2 and VARIETY 4). In the final baseline condition (Sessions 700 to 704; *cf.* Figure 5), different colors were correlated with FI reinforcement and EXT in each terminal link. The position of the two different colors (and, in the final baseline condition, their correlated schedules) alternated irregularly on the two keys over successive presentations of each terminal link. Color and schedule abbreviations as in Figure 5.

IV.) Apex-left filled triangles represent different-color or varied keys in left terminal links, apex-right filled triangles represent different-color or varied keys in right terminal links, and unfilled circles represent a baseline determination with informative different-color stimuli in both terminal links.

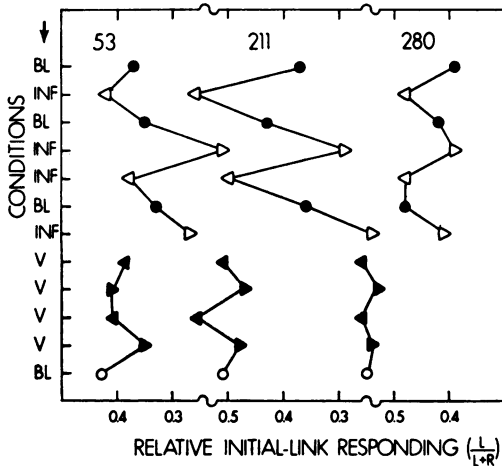


Fig. 8. Relative initial-link responding over successive conditions in the informative-stimulus and variety procedures. Baseline data for the informative-stimulus procedures are shown by filled circles; data for informative stimuli in left terminal links are shown by apex-left unfilled triangles, and for informative stimuli in right terminal links by apex-right unfilled triangles. Data for variety in left and right terminal links are shown respectively by apex-left and apex-right filled triangles; baseline data for this procedure are shown by unfilled circles. Details as in Figure 4.

For each pigeon, each change of conditions in Experiment III produced a shift in relative initial-link rate corresponding to a preference for terminal links that included informative stimuli. The exception was the last change from an informative-stimulus to a baseline condition for Pigeon 280 (as for the corresponding case in Figure 4, the relative rates, equal to two decimal places, did not constitute a reversal). Thus, 17 of 18 changes in schedule demonstrated that informative stimuli were preferred to uninformative stimuli. The effects were larger than those of free choice *versus* forced choice, but the approximate baseline levels and the ordering of the three pigeons in magnitudes of effect were comparable to those of Experiment 1.

With respect to stimulus variety, Pigeon 53's preferences were unsystematic, those of Pigeon 211 were small relative to the effects of in-

formative stimuli, and those of Pigeon 280 were absolutely as well as relatively small. The second sequence of free-choice *versus* forced-choice conditions, which immediately preceded Experiment IV chronologically, indicates that the outcome did not depend on the different changeover contingencies in Experiments III and IV or on a loss of the procedure's sensitivity to relevant variables.

DISCUSSION

Experiment III demonstrated that informative stimuli are preferred to uninformative stimuli. The concurrent chain schedules equated frequency of reinforcement and time to reinforcement in terminal links, and therefore avoided some difficulties of interpretation in prior studies. (Some relevant measures of terminal-link responding, such as responses per reinforcement, are presented below; they suggest that preferences for informative stimuli do not depend on properties of terminal-link responding.) In agreement with other research (*e.g.*, Schneider, 1972, Table 1), preferences for varied stimuli were small and inconsistent across pigeons.

But if informative stimuli are preferred to uninformative stimuli (perhaps even more strongly than free choice is preferred to forced choice), then the asymmetrical procedure of Experiment II on number of lit keys necessarily pitted free choice in one terminal link against informative stimuli in the other, and the symmetrical procedure necessarily confounded stimulus number with information. Thus, those results may be interpreted as an interaction of preferences for both free choice and informative stimuli.

Experiment IV on stimulus variety would have been unnecessary if Experiment III had presented different-color keys in both terminal links, correlating colors with FI reinforcement and EXT in one terminal link but not in the other. The present conditions were chosen, however, on the assumption that the stability and sensitivity of the several procedures depended at least in part on the consistencies in the different stimuli and locations of each initial and terminal link. Such procedural invariances probably contributed to the maintenance of differential control by terminal-link stimuli and the rapid adjustment of responding to changes in conditions.

SOME PROPERTIES OF THE INITIAL-LINK AND
TERMINAL-LINK PERFORMANCES

The present conclusions depend not only on the logic of classifying various terminal-link conditions and their combinations, but also on the properties of performances generated by concurrent chain schedules. This section examines initial-link responding and considers the parameters of terminal-link responding that might contribute to observed preferences.

Initial Links

Initial-link response rates and changeover rates averaged across the conditions of each procedure are summarized in Table 2. Consistent with simple concurrent performances (Catania, 1966), the change from COR 1 to COR 2 increased initial-link rates for Pigeon 53 and Pigeon 211, and increased changeover rates for all three pigeons. Rates decreased in the final procedure (IIb; cf. General Method).

Table 3 summarizes mean preference and differences in preference across the several procedures. In free-choice procedures, the change from free choice in left to free choice in right terminal links shifted preference a mean of

Table 2

Initial-link response rates (resp/min) and changeover rates (COs/min). Within each procedure, data are pooled across the last three sessions of each condition. During Ia, IIa, and III, COR 1 (no changeover contingency) operated; thereafter, COR 2 operated. Parentheses show session numbers.

Procedure	Pigeon:	Resp/min, both keys			COs/min, one-way		
		53	211	280	53	211	280
Ia (145-244)							
Baseline		55	50	62	17	17	21
Free versus forced choice, color		53	45	67	14	14	21
Free versus forced choice, position		55	42	65	16	13	20
IIa (251-286)							
Two-key versus one-key, asymmetrical		55	49	62	16	14	15
III (396-469)							
Informative stimuli		54	47	60	15	14	17
Ib (624-678)							
Free versus forced choice, color		65	59	54	12	9	8
IV (679-699)							
Stimulus variety		66	64	67	13	11	10
IIb (700-714)							
Two-key versus one-key, symmetrical		58	57	44	11	11	7

0.14 (Ia) or 0.12 (Ib) with color forced and of 0.10 (Ia) with position forced. In informative-stimulus procedures, the equivalent change shifted preference a mean of 0.17 (III). In the stimulus-number and variety procedures, however, these shifts in preference were, respectively, 0.04 (IIb) and 0.03 (IV). (The first stimulus-number procedure, IIa, is omitted because it did not vary terminal links symmetrically.)

The mean rate of reinforcement over both initial and terminal links was about 100 reinforcements per hour. By analogy with simple concurrent schedules, in which relative response rate approximately matches relative reinforcement rate (e.g., Herrnstein, 1961), a shift of 0.10 for X-on-the-left versus X-on-the-right implies that the change in the position of X is equivalent to a change of about 10 reinforcements per hour (i.e., from 55 versus 45 reinforcements per hour to 45 versus 55 reinforcements per hour). But such quantitative derivations suffer from the dimensional incompatibility of the preferred variables and the absence of parametric data on each variable. For example, informative stimuli are not measured in the same units as alternatives, and, although informative stimuli might be preferred to free choice under some conditions, the balance might be shifted simply by varying the number of alternatives.

The present experiments demonstrated directions of preference, but the quantitative analysis of concurrent-chain schedules remains controversial (e.g., Davison and Temple, 1973; Fantino, 1969), the transitivity of preferences within these schedules has been questioned (e.g., Navarick and Fantino, 1972), and circumstances have been demonstrated under which preferences reverse with parametric changes in the parameter values of initial-link schedules (Daniels, 1971). Baselines provides another complication: a 0.10 shift in preference from a baseline level of 0.35 cannot be treated as equivalent to a 0.10 shift from a baseline level of 0.50 (cf. Figures 4, 6, and 8). Thus, quantitative conclusions about relative magnitudes of preference in the present experiments must be drawn with caution.

Terminal Links

According to available evidence, characteristics of terminal-link responding such as rate and pattern do not substantially affect initial-

Table 3

Summary preferences for terminal-link X [as initial-link relative rate $L/(L+R)$]. Relative magnitudes of preference are given by the difference between X-on-left and X-on-right. IIa (asymmetrical) omitted.

Procedure	Pigeon:	X-on-left/X-on-right			Difference			
		53	211	280	53	211	280	Mean
I. Free choice (X) - forced choice:								
Ia. Color forced		0.46/0.31	0.64/0.46	0.54/0.46	0.15	0.18	0.08	0.14
Ia. Position forced		0.43/0.34	0.53/0.40	0.50/0.42	0.09	0.13	0.08	0.10
Ib. Color forced		0.44/0.32	0.51/0.31	0.63/0.58	0.12	0.20	0.05	0.12
II. Two stimuli (X) - one stimulus:								
IIb. Symmetrical		0.41/0.36	0.52/0.49	0.49/0.46	0.05	0.03	0.03	0.04
III. Informative stimuli (X) - uninformative stimuli		0.40/0.24	0.53/0.26	0.48/0.40	0.16	0.27	0.08	0.17
IV. Stimulus variety (X) - no stimulus variety		0.40/0.38	0.54/0.48	0.56/0.54	0.02	0.06	0.02	0.03

link preferences in concurrent chain schedules (Killeen, 1968, 1971; Neuringer, 1969; but see also Fantino, 1968). Free-choice and forced-choice terminal-links may generate different rates or patterns of responding, however, and preferences may depend upon the different patterns so generated. No consistent or obvious relation between temporal patterning and preference was evident from visual inspection of cumulative records; nevertheless, terminal-link response rates, presumably correlated with FI pauses and scalloping, were examined quantitatively.

Table 4 provides terminal-link response rates for each type of terminal link in each procedure. In free-choice procedures, each pigeon responded on both keys of each free-choice terminal link, and responded at about the same rate on those two keys together as on either key alone in a forced-choice terminal link. In left terminal links of Procedure Ia for Pigeon 53, for example, blue and amber respectively maintained 66 and 76 responses per minute when presented alone (forced choice), and a total of 73 responses per minute when presented together (free choice). The latter rate was the sum of 26 responses per minute maintained by blue and 47 responses per minute maintained by amber. Response rate also varied with key position. Independently of color, the left key maintained 22 responses per minute and the right key 51 responses per minute. (Note that left/right, in the body of Table 4, designates the two keys of a given terminal link, and not the terminal links them-

selves.) In no case did any pigeon respond exclusively on only one color or only one key of a free-choice terminal link.

In the second free-choice procedure (Ib), response rates for particular terminal-link colors differed more markedly, probably because this procedure followed earlier conditions in which amber and red were correlated with EXT (e.g., 37 and two responses per minute respectively for blue and amber in left free-choice terminal links for Pigeon 53). Differences in response rates on the two terminal-link keys appeared unrelated to magnitudes of preference for free-choice terminal links.

The change to EXT correlated with amber and/or red (Procedures IIa, IIb, and III) decreased the responding maintained by those colors. With respect to the argument that even FI and EXT in a terminal link provide a choice, note that rates as high as nine responses per minute (Pigeon 53, IIb, EXT on red in right terminal link) were sometimes maintained by the color correlated with EXT. The occasional succession of EXT pecks followed by reinforced FI pecks may have contributed to maintained responding on these keys. Preferences did not appear to vary with EXT rates.

In Procedure III (informative stimuli), rates sometimes differed on the two keys even when both terminal-link keys were the same color (e.g., Pigeon 53, blue in left terminal link). Possibly owing in part to prior EXT, larger rate differences occurred in Procedure IV (stimulus variety). Substantially different rates were maintained by different key positions as

Table 4

Absolute terminal-link response rates (resp/min) pooled across the last three sessions of each type of terminal link in each procedure: free choice (Ia, Sessions 164-244, and Ib, 641-678), stimulus number (IIa, 251-286, and IIb, 700-714), informative-stimulus (III, 396-469), and stimulus variety (IV, 679-699). Free-choice baseline data (145-163 and 624-640) were comparable to those shown under Ia and Ib (Color forced).

Procedure	Left Terminal Links	Pigeons			Right Terminal Links	Pigeons		
		53	211	280		53	211	280
Ia. Color forced	Blue alone	66	27	37	Green alone	59	20	38
	Amber alone	76	20	40	Red alone	74	20	38
	Blue/Amber (Left/Right)	26/47 22/51	12/9 11/10	28/14 29/13	Green/Red (Left/Right)	27/48 51/24	7/19 18/8	23/15 12/26
Ia. Position forced	Left alone	74	21	33	Left alone	70	24	26
	Right alone	84	41	42	Right alone	66	20	31
	Left/Right (Blue/Amber)	11/56 29/38	14/9 9/14	17/18 19/16	Left/Right (Green/Red)	38/38 9/67	26/7 13/20	14/26 28/12
Ib. Color forced	Blue alone	50	22	37	Green alone	44	21	38
	Amber alone	56	21	30	Red alone	58	17	36
	Blue/Amber (Left/Right)	37/2 18/21	26/5 23/8	35/4 24/15	Green/Red (Left/Right)	23/26 41/8	19/8 18/9	29/4 15/18
IIa. Asymmetrical	Blue (FI)/Amber (FI)	25/48	11/17	19/15	Green (FI)/Red (FI)	2/75	11/20	16/19
	Blue (FI)/Amber (EXT)	53/1	30/2	30/2	Green (FI)/Red (EXT)	42/8	28/8	34/2
	Blue (FI) alone	66	24	36	Green (FI) alone	50	22	28
IIb. Symmetrical	Blue (FI)/Amber (EXT)	53/1	30/2	30/2	Green (FI)/Red (EXT)	37/9	36/2	38/1
	Blue (FI) alone	66	24	36	Green (FI) alone	50	22	28
	Blue, Left/Right	31/15	15/18	22/11	Green, Left/Right	25/16	20/17	14/19
III. Informative	Blue (FI)/Amber (EXT)	42/5	28/2	35/2	Green (FI)/Red (EXT)	38/8	30/3	38/2
	Blue, Left/Right	36/10	13/14	15/3	Green, Left/Right	25/9	18/10	12/12
	Amber, Left/Right	58/4	5/25	15/7	Red, Left/Right	57/8	27/1	18/7
IV. Variety	Blue/Amber (Left/Right)	46/4 24/26	23/4 16/11	30/6 25/11	Green/Red (Left/Right)	23/35 52/6	25/7 23/9	38/2 20/20

well as by different colors in this procedure (e.g., Pigeon 53, right terminal link).

The time to reinforcement in terminal links equalled the 20-sec FI plus the time to the reinforced peck, and therefore depended on terminal-link performance. This duration was longest when FI reinforcement was scheduled for only one of two lit keys, because time spent pecking a lit EXT key added to terminal-link duration. The contribution of EXT-key pecking was greatest in the absence of informative stimuli, even though changeovers from one to the other terminal-link key were maximal in this condition. Nevertheless, response rates were sufficiently high that relative time to reinforcement rarely differed from 0.50 by more than ± 0.01 . Such differences in time to reinforcement are not large enough to account for observed preferences.

Another variable of potential interest is relative responses per reinforcement: pigeons might prefer terminal links that generated less responding (with equal FIs in both terminal links, relative responses per reinforcement is roughly equivalent to relative response rate). Figure 9 therefore presents relative terminal-link responses per reinforcement for each pigeon over all procedures. The organization and data symbols correspond to those of Figures 4, 6, and 8. The horizontal axis is scaled so that displacement to the right corresponds to fewer responses per reinforcement in right terminal links, and displacement to the left corresponds to fewer responses per reinforcement in left terminal links. If preference were correlated with this variable, the data would be patterned like the preferences of the earlier figures (or as their mirror images if more rather than fewer responses per reinforcement were preferred). In fact, no consistent patterning is evident. Thus, if properties of terminal-link performance determined preference, those properties must be more complex derivatives of responding than relative responses per reinforcement.

GENERAL DISCUSSION

The present experiments demonstrated preferences for free choice and for informative stimuli. Preference for number of stimuli was inconsistent or small, and preference for stimulus variety was absent or small. Although the free-choice procedure confounded number of alternatives with number of stimuli, the pref-

erence for free choice cannot be interpreted in terms of stimulus number because the stimulus-number procedure confounded number of stimuli with informative functions of stimuli.

In any study, the preference for free choice will inevitably be confounded with preference for other variables. For example, it may be interpreted as a preference for response variety: a single alternative makes only one highly probable response available, whereas two or more alternatives necessarily make two or more highly probable responses available. The preference may depend on the summation of these response probabilities, even though the responses cannot be emitted simultaneously once they are available.

Alternatives cannot be presented without accompanying stimuli, and these stimuli set the occasion for responding. The availability of alternatives might be spoken of in terms of presenting two or more conditioned reinforcers, setting the occasion for two or more discriminated operants, or providing the opportunity for two or more highly probable responses. These usages respectively emphasize stimuli, stimulus-response relations, and responses, but they do not imply procedural distinctions. The issue is not one of the empirical status of preference for free choice, but rather of the language in which it is discussed.

The present experiments examined preferences for alternative routes to the same reinforcer, rather than preferences for alternative reinforcers (*cf.* Brigham and Sherman, 1973; Steinman, 1968). In the latter situation, free choices and informative stimuli are inseparable, because different reinforcers cannot be chosen unless the stimuli correlated with those reinforcers are also available. In practice, the experimental difficulty is that the subject will choose the momentarily preferred reinforcer in the free-choice terminal link; the experimenter, however, must select the succession of forced choices in the other terminal link, and therefore may sometimes make the momentarily less-preferred reinforcer available. (This argument may also be extended to color and position preferences in the present free-choice procedures; on the assumption that such preferences do not change rapidly within sessions, however, the counterbalancing of forced-choice colors and positions reduces its plausibility.)

In any case, the preference for alternatives is consistent with other findings. The potent

effects of options or, equivalently, alternatives, have been demonstrated in the context of complex reinforcement schedules (Findley, 1962);

those schedules maintained response outputs that were orders of magnitude larger than those maintained by standard reinforcement schedules. The significance of a preference for alternatives also seems implicit in applied research, as when token economies provide a choice of reinforcers, or as when students' self-imposed contingencies are more effective than teacher-imposed contingencies in modifying academic behavior (Lovitt and Curtiss, 1969). It is fitting, too, that self-control can be exercised only in situations in which the organism has alternatives (Rachlin and Green, 1972); in this context, the concepts of freedom and responsibility meet (*cf.* Skinner, 1971, pp. 72 to 73).

On the assumption that the present data do depend on a preference for alternatives, the preference might be attributed either to ontogenetic or to phylogenetic origins (*cf.* Skinner, 1966). Interactions with the environment during an organism's lifetime might lead to such preferences. For example, if a pigeon's pecks on one key are ineffective and another key is available, switching to and pecking that other key may be reinforced. Such switching, and subsequent reinforcement, is not possible when no other key is available. Thus, the pigeon may simply learn, over the course of many experimental sessions, that one-key situations occasionally lead to long periods of nonreinforcement, whereas more-than-one-key situations do not.

The problem with this argument is that exposure to the different potential consequences of one-key and more-than-one-key situations need not be uniform over time or across organisms. Preference for two-key or free-choice terminal links might be expected to be largest after such exposure (*e.g.*, the several key failures during the omitted Sessions 287 to 395), and to diminish thereafter. But there was no evidence that magnitudes of preference for the present pigeons changed systematically or cumulatively over time or in relation to such exposures. Thus, the consistent individual differences in the magnitudes of preference reduce the plausibility of an ontogenetic argument. The argument might be extended to situations outside the experimental environment, but such an argument is not likely to be conclusive.

The generality of the present findings has yet to be established. Nevertheless, some speculation may be in order. A leap from the be-

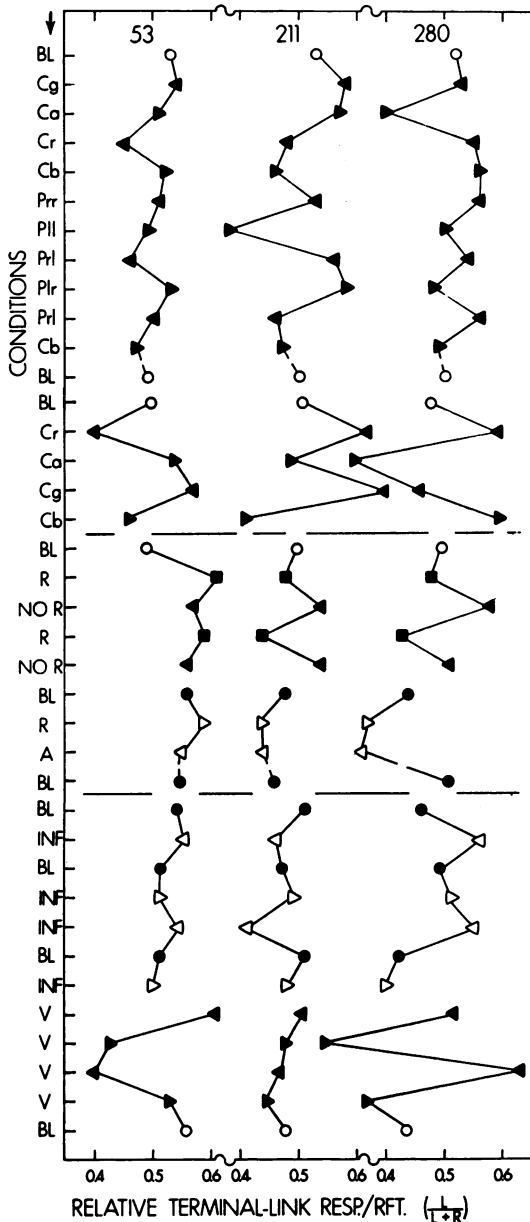


Fig. 9. Relative terminal-link responses per reinforcement for each pigeon across all conditions. The x-axis is scaled so that a displacement to the left corresponds to a decrease in the relative responses per reinforcement in the left terminal link, and a displacement to the right corresponds to an increase in the relative responses per reinforcement in the left terminal link. The various filled and unfilled symbols correspond to those in Figures 4, 6, and 8. Details in text; compare average absolute response rates in Table 3.

havior of pigeons to conclusions about the human condition would, of course, be presumptuous, no matter how tempting it might be to draw implications from pigeons' preferences for freedom and knowledge. It may be reasonable to assume, however, that organisms preferring situations that include alternatives and informative stimuli would be more likely to survive and therefore would have a reproductive advantage over organisms that did not have such preferences. But this implies that the preference for freedom and knowledge can arise phylogenetically. If such preferences are part of the phylogenetic endowment even of the pigeon, then corresponding human preferences take on a special significance, because they need no longer to be attributed merely to the practices of particular cultures. Freedom and knowledge may or may not be biologically fundamental; in either case, they have a place in the analysis of behavior.

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