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NEGATIVE BEHAVIORAL CONTRAST ON MULTIPLE TREADLE-PRESS SCHEDULES

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Eight pigeons pressed treadles for food reinforcers delivered by several multiple variable-interval schedules. The rate of reinforcement for responding during one component schedule was held constant at 30 reinforcers per hour. The rate of reinforcement for responding during the other component varied from 0 to 120 or 240 reinforcers per hour. The schedules were presented in different orders for different subjects. The rate of responding emitted during the variable component schedule varied directly with the rate of reinforcement it provided. The rate of responding during the constant component did not increase consistently when the rate of reinforcement obtained from the variable component decreased from 30 to 0 reinforcers per hr. The rate of responding emitted during the constant component decreased when the rate of reinforcement obtained from the variable component increased from 30 reinforcers per hour to a higher rate. That is, negative but not positive behavioral contrast occurred. The failure to find positive contrast is consistent with one of the predictions of the additive theories of behavioral contrast. Finding negative contrast has ambiguous implications for the additive theories.

Key words: behavioral contrast, multiple schedule, variable-interval schedule, additive theory, treadle press, pigeons.

Several additive theories have been proposed to describe the behavioral contrast that occurs when pigeons peck keys for food reinforcers delivered by multiple schedules (Gamzu and Schwartz, 1973; Hearst and Jenkins, 1974; Rachlin, 1973). Behavioral contrast may be defined as an inverse relation between rate of responding emitted during one component of a multiple schedule (the constant component) and rate of reinforcement obtained from the other component (the variable component). Positive contrast has been defined as an increase in the rate of responding that occurs during the constant component when the rate of reinforcement obtained from the variable component decreases. Negative contrast has been defined as a decrease in the rate of responding emitted during the constant component that occurs when the variable rate of reinforcement increases.

The additive theories argue that positive contrast occurs when elicited responses add to instrumental responses. Instrumental responses are governed by the relation between the subject's responses and the reinforcers they obtain. Elicited responses are governed by some aspect of the relation between stimuli and the reinforcers that occur in their presence. The additive theories differ in their characterization of this relation, but they agree that elicited responses appear when subjects respond on autoshaping (Brown and Jenkins, 1968) and on negative automaintenance procedures (Williams and Williams, 1969). They also agree that elicited responses will add to instrumental responses only when the elicited responses resemble or facilitate the instrumental responses. Elicited responses will not add to instrumental responses when they interfere with instrumental responding or when they are not recorded by the experimenter.

The additive theories differ in their explanations of negative contrast. Schwartz (1975) rejected an additive theory of negative contrast, but Hearst and Jenkins (1974) and Rachlin (1973) proposed additive theories. They argued that the decrease in the rate of responding, which is labelled negative contrast, results from elicited responding interfering with or inhibiting instrumental responding. Hearst and Jenkins argued that animals direct their

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behavior away from stimuli that are poorer predictors of reinforcement. Rachlin argued that the transitions from stimuli that signal higher rates of reinforcement to ones that signal lower rates inhibit elicited responses. Inhibited elicited responses may subtract from the rate of emitting other responses. In either case, negative contrast may be observed when the rate of reinforcement provided by the variable component schedule changes from a rate equal to that supplied by the constant component to a rate higher than that supplied by the constant component. The transition from the variable component to the constant component now represents a transition from a higher to a lower rate of reinforcement. According to Hearst and Jenkins, the rate of responding emitted during the constant component will decrease, producing negative contrast, if the animals direct their behavior away from the stimulus that signals that component. According to Rachlin, negative contrast will appear if inhibited elicited responses subtract from the rate of instrumental responding emitted during the constant component.

The additive theories have been supported by the finding that positive behavioral contrast does not appear when pigeons press treadles for food reinforcers delivered by multiple schedules (Hemmes, 1973; Westbrook, 1973). The theories predict that positive contrast should not be observed because pigeons direct pecks at the stimulus that signals food. Such stimuli typically occur on the pecking key during multiple schedules that use the pecking response. In the treadle studies, the stimuli were spatially separated from the manipulanda. Elicited responses should not add to instrumental responses when pigeons press treadles because the elicited responses will be unrecorded pecks on the stimuli that signal the component schedules, not recorded presses on the treadles.

The rate of responding emitted by pigeons pressing treadles for food reinforcers delivered by multiple schedules deserves further investigation. First, the interpretation of past failures to find positive contrast in this situation should be clarified. Poor discrimination between the component schedules, rather than differences between key-peck and treadle-press responding, may have produced the absence of positive contrast in the Westbrook (1973) study. Second, negative contrast should also be studied. Schwartz (1975) showed that the variables that effect positive contrast need not effect negative contrast. Therefore, negative contrast might occur when pigeons press treadles for food reinforcers, even though positive contrast does not occur. The present experiments addressed these problems. They employed a two-treadle procedure, shown by preliminary work to improve discrimination between the component schedules, and they studied negative as well as positive contrast.

EXPERIMENT I

Method

Subjects

Four homing pigeons, maintained at 80 to 85% of their free-feeding body weights, all had experience pecking keys for food reinforcement. None had pressed treadles.

Apparatus

A standard three-key Grason-Stadler pigeon station, model E6446C, enclosed in a Grason-Stadler, model E3125A-300, sound-attenuating chamber, had two floor treadles added to the enclosure. Each treadle, a 5.2-cm diameter aluminum disc, was held in a resting position 2.6 cm above the enclosure floor by a strip of aluminum, which connected it to the wall containing the magazine. The aluminum strips were 7.7 cm long by 1 cm wide. They entered the wall containing the magazine 16.8 cm below each of the two outer response keys. The centers of the keys were located approximately 19 cm apart, and 8 cm from one of the side walls of the apparatus. The treadles produced a brief feedback click when operated by a force greater than approximately 0.25 N applied to their centers. A houselight located in the upper-right corner of the wall containing the magazine illuminated the chamber throughout the session. White noise was present throughout the sessions. Electromechanical equipment located in another room scheduled the experimental events.

Procedure

Each subject was trained to press both treadles with its feet by a successive approximations procedure. Shaping produced a response in which the pigeon usually stood near

the center of the apparatus and faced the wall that contained the magazine. It placed one foot on the treadle and moved this foot up and down to operate it. Moving from one treadle to the other required that the subject cross the chamber and place a foot on the other treadle.

The subjects were trained to press both treadles by shaping successively closer approximations to pressing each treadle, and by discontinuing reinforcers for one treadle if they pressed that one to the exclusion of the other. When the subjects first pressed the treadles they were given continuous reinforcement. This was followed by several fixed-ratio schedules of increasingly greater response requirements. Then, subjects were placed on a variable-interval 15-sec (VI 15-sec) schedule followed by a VI 30-sec schedule, followed by a VI 1-min schedule. The same schedules were presented on both treadles during shaping. Shaping continued on each schedule until the subjects responded at a high steady rate on both treadles.

Then, the subjects were placed on a series of multiple schedules. The multiple schedules presented are shown in Table 1 in order of presentation. Table 1 also presents the number of sessions for which each subject responded on each schedule. The *mult* VI 2-min VI 2-min schedule was presented after each of the other schedules in order to distinguish changes in the rate of responding, which represent behavioral contrast from fluctuations in the rates of responding that occurred over time (Schwartz, 1975).

The subjects worked on each schedule until five days of stable responding had been recorded. Responding was considered to be stable when the rates of responding emitted during each component schedule, during each of the last five sessions for which a schedule was presented, fell within the range of rates emitted during that component in the earlier sessions. That is, a range of rates of responding was calculated for each component schedule by looking at the rates of responding emitted by a particular subject during all but the last five sessions for which that component schedule was presented. Responding was considered to be stable for that subject, responding on that component, if the rates of responding emitted during the last five sessions fell within this range. Responding was considered to be stable for a multiple schedule only when the rates of responding emitted during both components were stable.

Table 1

Schedules, in order of presentation, with the number sessions for which each subject responded on each schedule.

Schedule	Subject 99	61	1442	1473
EXPERIMENT I				
mult VI 2-min VI 2-min	46	30	32	35
mult VI 2-min EXT	53	33	54	41
mult VI 2-min VI 2-min	27	35	21	35
mult VI 2-min VI 30-sec	31	24	24	28
mult VI 2-min VI 2-min	32	46	35	31
mult VI 2-min VI 1-min	26	26	35	28
mult VI 2-min VI 2-min	18	22	22	33
mult VI 2-min VI 15-sec	28	29	16	32
mult VI 2-min VI 2-min	34	30	26	19
mult VI 2-min VI 20-sec	15	32	28	25
mult VI 2-min VI 2-min	20	22	22	25
	Subject			
	6443	*3174*	*1530*	*60*
EXPERIMENT II				
mult VI 2-min VI 30-sec	19	20	33	18
mult VI 2-min VI 2-min	21	19	24	22
mult VI 2-min EXT	32	30	31	33
mult VI 2-min VI 2-min	20	16	16	16

Reinforcers for each schedule were presented according to a 20-interval series constructed by the procedure outlined in Catania and Reynolds (1968, Appendix II). The components alternated in time every 2 min. A red light illuminated the key above the left treadle when that treadle provided reinforcement, which consisted of 5-sec access to grain. A white light illuminated the key above the right treadle when that treadle provided reinforcement. Both lights were extinguished and no presses were recorded during food presentations. The right treadle presented the VI 2-min component of each schedule.

Sessions were conducted daily, six to seven times per week. Sessions terminated after 40 reinforcers had been delivered for all schedules except the *mult* VI 2-min extinction (EXT) schedule. Sessions terminated after 20 reinforcers for this schedule to prevent them from becoming excessively long.

RESULTS

Figure 1 contains the average rates of responding emitted during the two components of each multiple schedule presented in the

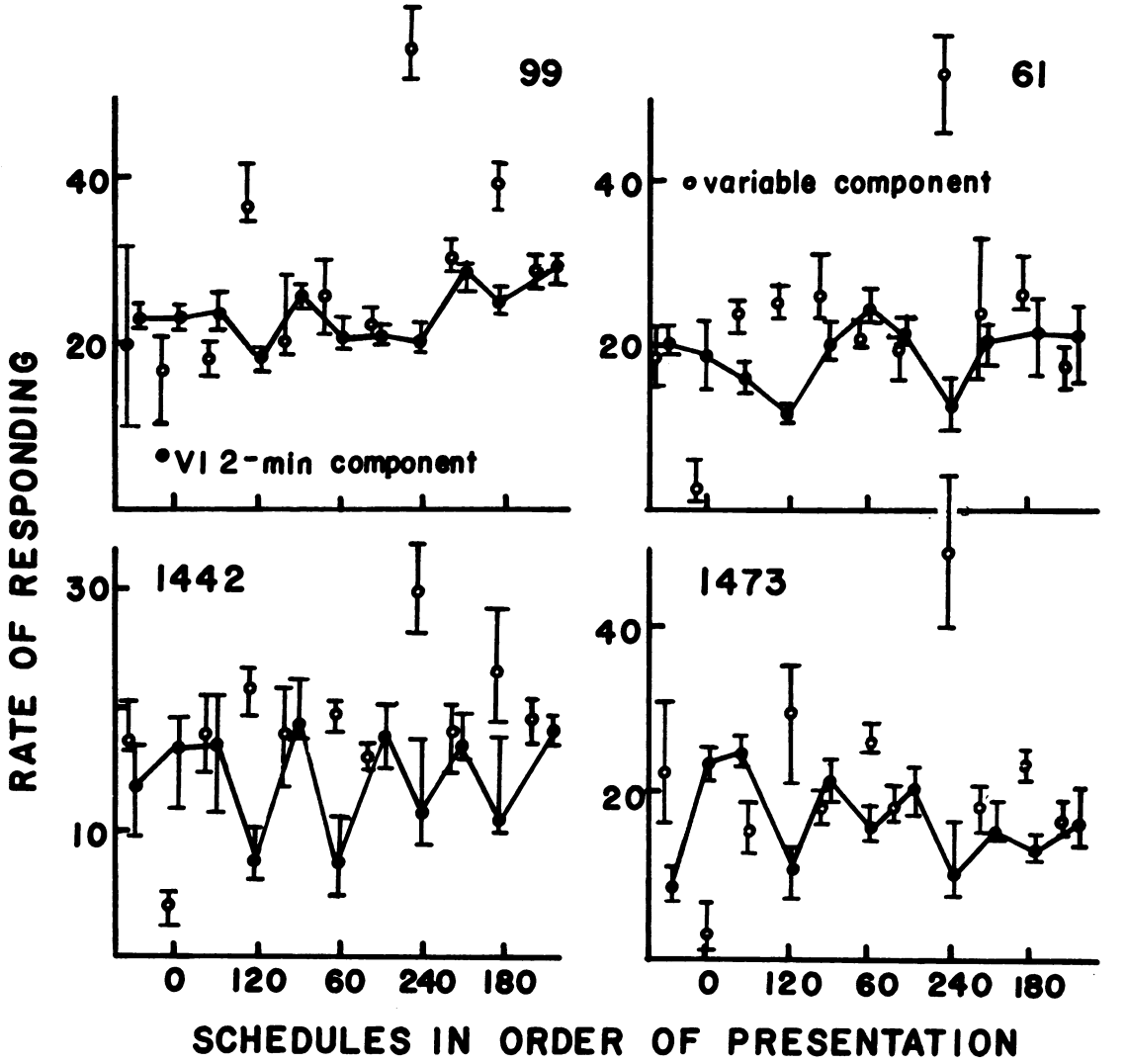

Fig. 1. Rates of responding emitted during the two components of each multiple schedule in the order in which the schedules were presented. The rates are the means of the rates emitted during the last five sessions for which each schedule was available, reported in presses per minute. The solid points represent the rates of responding emitted during the constant components. The open points represent the rates of responding emitted during the variable components. The vertical lines represent the range of the rates of responding emitted during a component schedule over the last five sessions for which that schedule was presented. Each set of axes represents an individual subject. For convenience, the abscissa has been labelled with the number of reinforcers presented per hour during the variable component schedule. The points generated by the *mult* VI 2-min VI 2-min schedules have not been labelled. The lines connect the rates of responding emitted during the constant component schedules.

order in which the schedules were conducted. Each point represents the mean of the rates of responding emitted during the last five sessions for which that schedule was available. The vertical lines indicate the range of the rates of responding emitted during that component schedule over those sessions. All rates of responding are local rates, calculated by dividing the number of responses emitted during a component schedule by the time for which that component was available. The rates include only responses emitted on a treadle when the component associated with that treadle was available. For convenience, the abscissa has been labelled with the numbers of reinforcers per hour collected from the

variable component schedules. The points generated by the *mult* VI 2-min VI 2-min schedules have not been labelled. A solid line connects the points representing the rates of responding emitted during the constant component schedules to facilitate comparisons.

The results presented in Figure 1 lead to several conclusions. First, discrimination between the component schedules was good: the rates of responding emitted during the components differed when the rates of reinforcement they provided differed. Second, the rates of responding emitted during the variable component schedules usually increased with increases in the rates of reinforcement provided by those components. Third, positive contrast usually appeared when it was defined as any increase in the rates of responding emitted during the constant component schedule that occurred when the rate of reinforcement obtained from the variable component decreased. Each of the four subjects experienced five transitions from a multiple schedule, in which the variable component supplied a higher rate of reinforcement, to one in which it supplied a lower rate. The rates of responding emitted during the constant component schedule increased in 17 of these 20 cases. Fourth, negative behavioral contrast usually appeared when it was defined as any decrease in the rate of responding emitted during the constant component schedule that occurred when the rate of reinforcement obtained from the variable component increased. Again, each of the four subjects experienced five transitions from a variable component that supplied a lower rate of reinforcement to one that supplied a higher rate. The rate of responding emitted during the constant component decreased in 16 of 20 cases.

Figure 1 also shows that the transition from a multiple schedule that supplied equal rates of reinforcement in the component schedules to one that supplied unequal rates did not produce the same effect on behavior as a transition from a multiple schedule that supplied unequal rates to one that supplied equal rates. Fifteen of the 17 instances of positive behavioral contrast occurred when subjects moved from schedules that supplied higher rates of reinforcement in the variable component back to the *mult* VI 2-min VI 2-min schedule. The rate of responding emitted by only two of the four subjects clearly increased when they moved from the *mult* VI 2-min VI 2-min schedule to the *mult* VI 2-min EXT schedule. Fifteen of the 16 instances of negative contrast occurred when subjects moved from the *mult* VI 2-min VI 2-min schedule to a schedule that supplied a higher rate of reinforcement during the variable component. Negative contrast occurred for only one of the four subjects when they moved from the *mult* VI 2-min EXT schedule back to the *mult* VI 2-min VI 2-min schedule.

Figure 2 presents the rates of responding shown in Figure 1 plotted as changes from a baseline rate of responding. Changes in the rates of responding were calculated as follows. The five-day means of the rates of responding emitted on the right treadle of the *mult* VI 2-min VI 2-min schedule, which preceded and followed each other schedule, were averaged to provided a baseline rate or responding for that treadle for the intervening schedule. The rates of responding emitted on the left treadle of the *mult* VI 2-min VI 2-min schedules were also averaged to provide a baseline rate of responding for that treadle for each intervening schedule. Then, these baseline rates were subtracted from the rates of responding emitted on these treadles during the intervening schedules. The changes are plotted as a function of the rates of reinforcement provided by the variable components of the intervening schedule, in reinforcers per hour.

Figure 2 shows that the rates of responding emitted during the variable component schedule usually increased with increases in the rate of reinforcement supplied by that component. Figure 2 also shows that the rate of responding emitted during the constant component was not consistently higher when the rate of reinforcement supplied by the variable component was zero reinforcers per hour than when it was 30 reinforcers per hour. Third, Figure 2 shows that the rate of responding emitted during the constant component was lower than its baseline rate for 14 of 16 points when the rate of reinforcement supplied by the variable component was greater than 30 reinforcers per hour. The size of the difference between the rate of responding emitted during the constant component and its baseline rate increased with increases in the rate of reinforcement supplied by the variable component up to 120 reinforcers per hour; then, it decreased.

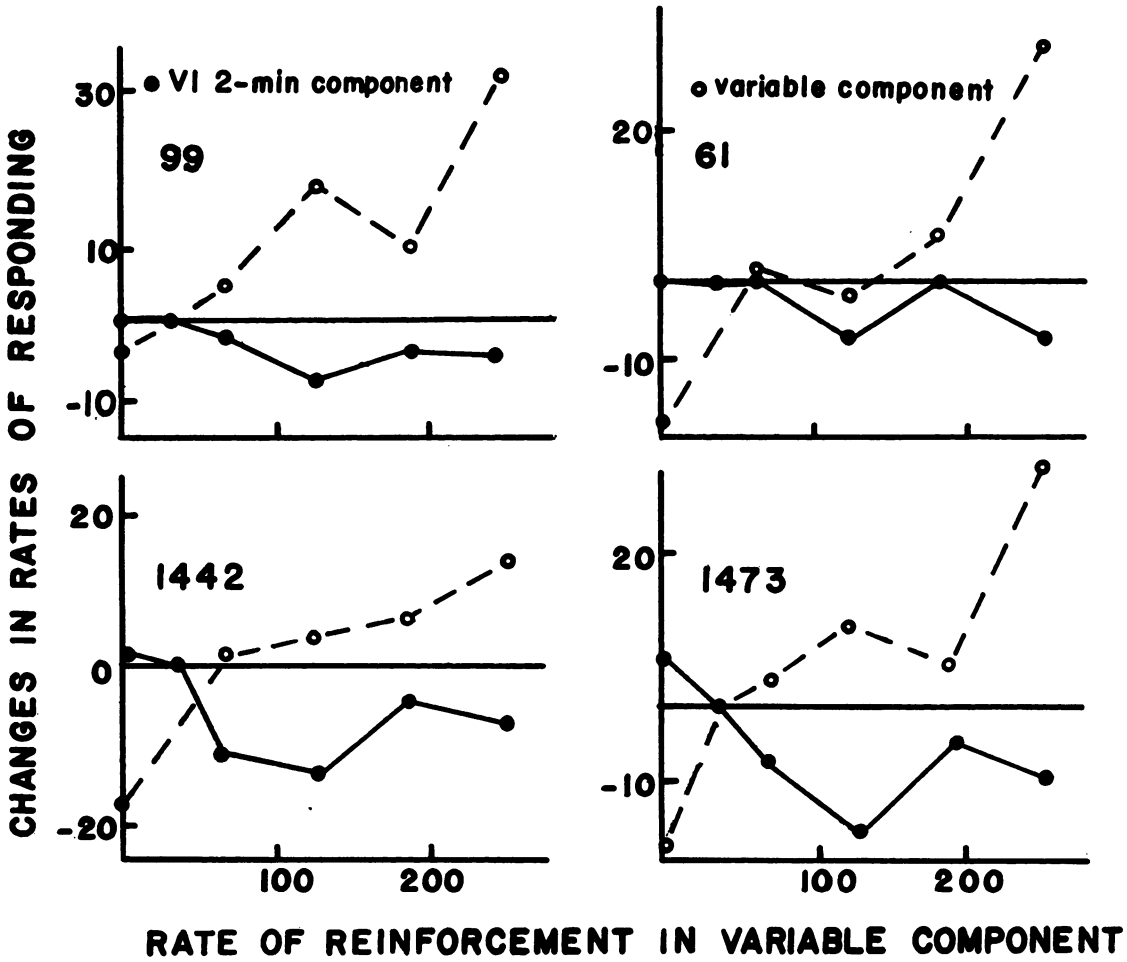

Fig. 2. Changes in the rates of responding emitted during the component schedules plotted as a function of the rates of reinforcement obtained from the variable component schedules. The five-day means of the rates of responding emitted during the components of the *mult* VI 2-min VI 2-min schedule that preceded and followed each intervening schedule were averaged to provide baseline rates of responding. These baseline rates were subtracted from the five-day means of the rates of responding emitted during the corresponding component of the intervening schedule. The results have been plotted as a function of the rate of reinforcement obtained from the variable component of the intervening schedule. Changes in rates of responding have been reported in responses per minute; rates of reinforcement, in reinforcers per hour. Each set of axes represents an individual subject. The filled points represent changes in the rates of responding emitted during the constant components, the open points represent changes in the rates of responding emitted during the variable components.

Figure 3 presents session-by-session results for Subject 1473. It presents session-by-session differences between the response rates emitted during the constant components of the schedules that supplied unequal rates of reinforcement in the two components, and the baseline rates of responding calculated for those components. The rate of responding emitted during each session was calculated by dividing the number of responses emitted during the constant component by the time for which the component was available minus the magazine time. The baseline rates of responding were calculated as they were for Figure 2. Points above the line, which represents no difference between the rates of responding and the baseline rate of responding, may represent positive behavioral contrast. Points below the line may represent negative contrast.

Figure 3 shows that negative contrast appeared consistently across sessions when the rate of reinforcement obtained by responding during the variable component schedule was greater than 30 reinforcers per hour. Positive

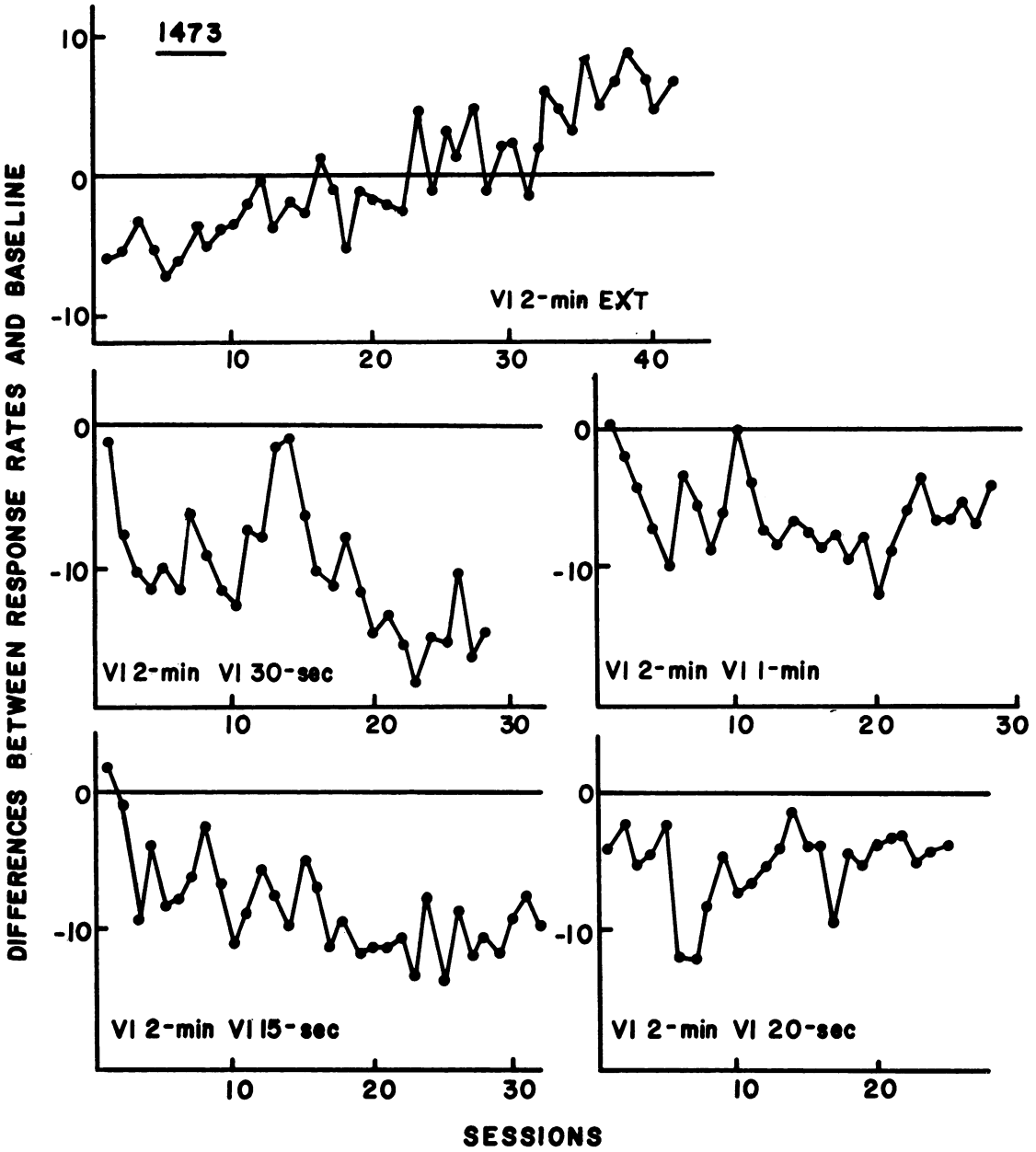

Fig. 3. Session-by-session changes in the size of behavioral contrast for Subject 1473, in responses per minute. Each set of axes represents the session-by-session responding emitted during one multiple schedule. Each point represents the difference between the rate of responding emitted during the constant component of that multiple schedule in a single session, and the baseline rate of responding emitted during that component. Baseline rates of responding have been calculated by averaging the five-day means of the rates of responding emitted during the constant component of the *mult* 2-min VI 2-min schedule that preceded and followed each of the intervening schedules. Points above the horizontal line in the top set of axes represent positive behavioral contrast. Points below the horizontal line in the other set of axes represent negative contrast.

contrast did not occur for the *mult* VI 2-min EXT schedule during the early sessions with this schedule, but it did appear during the later sessions.

EXPERIMENT II

Experiment I presented the *mult* VI 2-min EXT schedule before it presented any of the

other schedules that supplied unequal rates or reinforcement in the two components. Positive contrast did not occur when the subjects moved to the *mult* VI 2-min EXT schedule, but negative contrast did occur when subjects moved to the other unequal schedules. It might be argued that positive contrast would have appeared if the schedules had been presented in a different order. Experiment II tested this hypothesis by presenting some of the multiple schedules in a different order. It studied negative behavioral contrast before positive contrast, and began with multiple schedules that provided unequal rates of reinforcement in the two components before proceeding to ones that presented equal rates.

Method

Subjects

Four pigeons, maintained at 80 to 85% of their free-feeding body weights served. Subjects 3174 and 1530 were White Carneaux pigeons; Subjects 6443 and 60 were homing pigeons. All subjects had had experience pecking keys for food reinforcers. None had pressed treadles.

Apparatus

The apparatus was identical to that used in Experiment I.

Procedure

The procedure was identical to that used in Experiment I except that the subjects responded on the schedules in a different order. The schedules presented, and the number of sessions each was available, appear in Table 1 in order of presentation. The left treadle presented the VI 2-min component of each multiple schedule. Stability criteria were identical to those of Experiment I.

Results

Figure 4 contains the rates of responding emitted during the two components of each multiple schedule presented in the order in which the schedules were conducted. Again, the rates are the means of the local rates of responding emitted during the last five sessions for which each schedule was available. The vertical lines represent the range of rates of responding emitted during each component calculated over the last five sessions for which that schedule was available. The schedules have been labelled according to the number of reinforcers per hour obtained from the variable component schedules, for convenience. The points generated by the *mult* VI 2-min VI 2-min schedule have not been labelled. A line connects the points representing the rates of responding emitted during the constant component schedules to facilitate comparisons.

Figure 4 shows that the rate of responding emitted during the variable component schedule increased as the rate of reinforcement supplied by that component increased. Second, Figure 4 shows that the rate of responding emitted during the constant component schedule increased in four of eight cases when the rate of reinforcement supplied by the variable component decreased. Third, all four of these increases occurred when subjects moved from

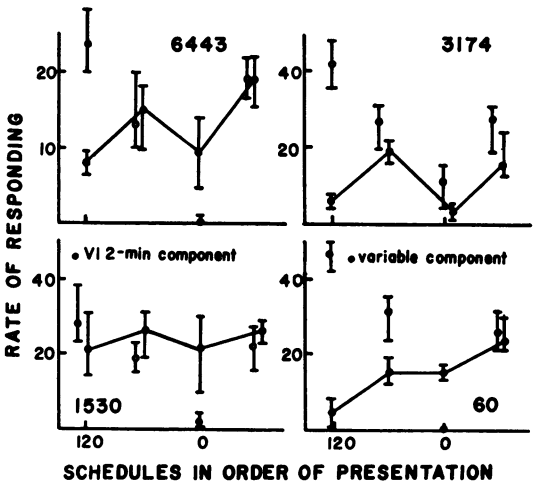

Fig. 4. Rates of responding emitted during the two components of each multiple schedule in the order in which the schedules were presented. The rates are the means of the rates emitted during the last five sessions for which each schedule was available, reported in presses per minute. The solid points represent the rates of responding emitted during the constant components. The open points represent the rates of responding emitted during the variable components. The vertical lines represent the range of the rates of responding emitted during a component schedule over the last five sessions for which that schedule was presented. Each set of axes represents an individual subject. The abscissa has been labelled with the number of reinforcers presented per hour during the variable component of that schedule. The points generated by the *mult* VI 2-min VI 2-min schedules have not been labelled. The lines connect the rates of responding emitted during the constant component schedules.

the *mult* VI 2-min VI 30-sec to the *mult* VI 2-min VI 2-min schedule. None of them occurred when subjects moved from the *mult* VI 2-min VI 2-min to the *mult* VI 2-min EXT schedule. Fourth, Figure 4 shows that the rate of responding emitted during the constant component schedule did not decrease for any subject when the rate of reinforcement supplied by the variable component increased from zero to 30 reinforcers per hour. But the rate of responding emitted during the constant component of the *mult* 2-min VI 30-sec schedule was lower than the rate emitted during the same component of the *mult* VI 2-min VI 2-min schedule that followed it, for all four subjects.

GENERAL DISCUSSION

The present experiments support several conclusions. First, Figures 1, 2, and 4 show that the rate of responding emitted during the variable components of several multiple treadle-press schedules increased with increases in the rates of reinforcement supplied by those components.

Second, negative behavioral contrast occurred during Experiment I, but not during Experiment II, if negative contrast is defined as any decrease in the rate of responding emitted during the constant component schedule that occurred when the rate of reinforcement obtained from the variable component increased. Negative behavioral contrast occurred in 16 of 20 cases in Experiment I, according to this definition. But negative contrast did not occur for any subject in Experiment II when the subjects moved from the *mult* VI 2-min EXT schedule to the *mult* VI 2-min VI 2-min schedule.

Third, positive behavioral contrast also occurred in Experiment I, but not in Experiment II, if positive contrast is defined as any increase in the rate of responding emitted during the constant component that occurred when the rate of reinforcement obtained from the variable component decreased. Positive behavioral contrast occurred in 17 of 20 cases in Experiment I, but occurred in only four of eight cases in Experiment II, according to this definition.

Fourth, Experiments I and II showed that the transition from multiple schedules that supplied equal rates of reinforcement in the two component schedules to ones that supplied unequal rates did not produce the same effect on behavior as transitions from schedules that supplied unequal rates to ones that supplied equal rates. Fifteen of the 17 instances of positive behavioral contrast in Experiment I, and four of the instances in Experiment II, appeared when subjects moved from a multiple schedule that supplied a rate of reinforcement greater than 30 reinforcers per hour in the variable component schedule to one that supplied 30 reinforcers per hour in both components. Only two instances of positive contrast in Experiment I and none in Experiment II occurred when subjects moved from the *mult* VI 2-min VI 2-min to *mult* VI 2-min EXT schedule. Fifteen of the 16 instances of negative behavioral contrast in Experiment I occurred when subjects moved from the *mult* VI 2-min VI 2-min schedule to a schedule that supplied a higher rate of reinforcement during the variable component. Three of the four failures to find negative contrast in Experiment I and all of the failures to find it in Experiment II occurred when subjects moved from the *mult* VI 2-min EXT schedule to the *mult* VI 2-min VI 2-min schedule.

These results may be summarized easily and consistently if the definition of behavioral contrast is changed. The change in definition would consider the rates of responding emitted during multiple schedules that supplied equal rates of reinforcement in the component schedules to be baseline rates of responding, which could be used to evaluate the appearance of positive or negative behavioral contrast. The term "positive contrast" would be restricted to increases in the rates of responding that occurred during the constant component schedule when the rate of reinforcement supplied by the variable component decreased from its baseline rate. The term "negative contrast" would be reserved for decreases in the rate of responding that occurred during the constant component when the rate of reinforcement supplied by the variable component increased from its baseline rate. According to these definitions, any increase in the rates of responding that occurred when subjects moved from a schedule that supplied a higher rate of reinforcement during the variable component to one that supplied an equal rate would be viewed as the disappearance of negative

contrast, rather than the appearance of positive contrast. Any decrease in the rate of responding that occurred when subjects moved from a schedule that supplied a lower rate of reinforcement during the variable component to one that supplied an equal rate would be viewed as the disappearance of positive contrast, rather than the appearance of negative contrast.

Figure 2 shows how these definitions clarify the results of Experiment I. According to these definitions, the points in Figure 2 that represent the constant component schedule also represent positive contrast if they fall above the horizontal line at no change from the baseline rate of responding, when the rate of reinforcement supplied by the variable component schedule is less than 30 reinforcers per hour. Points for the constant component schedule represent negative behavioral contrast if they fall below the line when the rate of reinforcement supplied by the variable component is greater than 30 reinforcers per hour. Figure 2 shows that negative behavioral contrast occurred in 14 of 16 cases. Positive behavioral contrast occurred for two subjects, but not for the other two.

These definitions also clarify the results of Experiment II. Figure 4 also shows that negative but not positive contrast appeared by these definitions. Positive contrast did not appear because the rate of responding emitted during the constant component of the *mult* VI 2-min EXT schedule was not higher than it was during baseline for any subject. Negative contrast did occur because the rate of responding emitted during the constant component of the *mult* VI 2-min VI 30-sec schedule was lower than it was during baseline for all subjects.

The revised definitions of behavioral contrast lead to the conclusion that negative but not positive contrast occurred consistently in Experiments I and II. The failure to find positive contrast is consistent with the additive theories of behavioral contrast. As stated earlier, the theories predict that positive contrast should not appear when pigeons press treadles for food reinforcers delivered by multiple schedules. The failure to find positive contrast consistently in the present experiments extends the results of the studies by Hemmes (1973) and Westbrook (1973) to different subjects, different treadles, and a different order of schedule presentation. It also shows that past failures to find positive contrast were not artifacts of some procedural details. Positive contrast failed to appear regardless of the order of presenting the schedules, and it failed to appear when the discrimination between the component schedules was good.

However, Figure 3 suggests that further research might yield results contradictory to the additive theories. Positive contrast may have occurred during the later sessions for Subject 1473. A similar trend occurred in the rates of responding emitted by Subject 1442, but not in the rates emitted by Subjects 99 and 61, or by the subjects in Experiment II. But increases in the rates of responding, which represent positive contrast, might have appeared for these subjects if the *mult* VI 2-min EXT schedule had been presented for longer periods of time.

Finding negative contrast has ambiguous implications for the additive theories. Finding negative contrast without finding positive contrast is compatible with an argument against an additive theory of negative contrast offered by Schwartz (1975). According to Schwartz, negative contrast may appear in situations that do not produce positive contrast. The two types of contrast result from different factors. Therefore, one set of factors may occur without the other. But the present results may also be compatible with the additive theories of negative contrast, especially that proposed by Hearst and Jenkins (1974). As stated earlier, Hearst and Jenkins argued that subjects direct their behavior away from stimuli that are poorer predictors of reinforcement. The stimulus that signals the constant component schedule becomes a poorer predictor of reinforcement when the rate of reinforcement supplied by the variable component increases from a rate equal to that supplied by the constant component to a rate higher than that supplied by the constant component. A decrease in rate of responding, which would be labelled negative contrast, might appear if directing behavior away from the stimulus that signalled the constant component interfered with the performance of the instrumental response. This theory provides a plausible account of the present results. The discriminative stimuli were located directly above the treadle. A subject that moved

away from these stimuli during the constant component schedule might have difficulty pressing the treadle.

One testable difference between the theory of negative contrast proposed by Hearst and Jenkins and that proposed by Schwartz is that Hearst and Jenkins predicted that the physical location of the discriminative stimuli and response manipulanda should determine whether negative contrast will be observed. The theory proposed by Schwartz may not make this prediction. The present experiment should be repeated using multiple schedules that vary the location of the treadle and the discriminative stimuli, and that produce good discrimination between the component schedules.

Another experiment might clarify the form of the function shown in Figure 2. The size of negative behavioral contrast appeared to increase with increases in the rate of reinforcement up to 120 reinforcers per hour, and then to decrease with further increases in reinforcement rate. However, Figure 2 might also show that the size of negative behavioral contrast decreased over time. The points presented in Figure 2 were conducted in the following order: 120, 60, 240, and 180 reinforcers per hour. The size of negative behavioral contrast did not decrease in exactly that order for any subject. But the order of presentation cannot be ruled out as an explanation for the generally smaller size of contrast for the points for 180 and 240 reinforcers per hour, which were the last points to be conducted.

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