JOURNAL OF THE EXPERIMENTAL ANALYSIS OF BEHAVIOR 1990, 54, 273-291 NUMBER 3 (NOVEMBER)

THE EFFECTS OF VERBAL PERFORMANCE DESCRIPTIONS ON NONVERBAL OPERANT RESPONDING

LAINE J. TORGRUD AND STEPHEN W. HOLBORN

UNIVERSITY OF MANITOBA

The effect of reinforced verbal descriptions on key-pressing rate was studied in the context of reinforcement for pressing on schedules opposed to the verbal description and schedules delivering a constant or randomly chosen point value regardless of pressing rate (nondifferential schedules). Undergraduates' key presses produced points exchangeable for lottery tickets on alternating schedules. Subjects experienced one of four manipulations. In Experiment 1, after schedule control had been demonstrated using a "medium rate" schedule for each of two response keys, subjects were awarded maximum points for choosing one of five verbal descriptions of "the best way to earn points" for each key. Subjects experienced either (a) maximum points for verbal descriptions of "press very fast" for one key and "press very slowly" for the other, with the schedule gradually moved from medium to oppose this description, or (b) maximum schedule points for a very fast rate on one key and very slow rate on the other, with the maximum points for verbal descriptions gradually moved to oppose the schedule. Key-pressing rates conformed to the active schedule, not to the verbal performance description. In Experiment 2 subjects received maximum points for verbal descriptions of "press very fast" for one key and "press very slowly" for the other while the same nondifferential schedule was operative for both keys. Correspondence of pressing rate to verbal description was either complete, transient, or absent. The precise discriminative control of the schedules employed may account for less verbal response-rate control in the present versus past research. Possible differences between computer- and experimenter-generated verbal behavior are discussed.

Key words: schedules, rule-governed behavior, instructions, verbal control, computer, key press, adults

---

Verbal and nonverbal behavior constitute two broad operant classes that may be of interest in any study employing human subjects. Although these operant classes of behavior are often studied independently, substantial interrelationships may exist between the two. For example, overt nonverbal responses indicating "remembering" may be mediated by private or overt verbal behavior (Skinner, 1969). A number of human operant studies (e.g., Harzem, Lowe, & Bagshaw, 1978; Hayes, Brownstein, Zettle, Rosenfarb, & Korn, 1986; Leander, Lippman, & Meyer, 1968; Matthews, Catania, & Shimoff, 1985) have begun to investigate directly the relationships between verbal and nonverbal behavior.

This research was conducted while L. J. Torgrud was supported by a Natural Sciences and Engineering Research Council of Canada fellowship. We gratefully acknowledge the assistance of Michael Dyck in writing the computer program for this project. In addition, our thanks to Gloria Eldridge for her invaluable comments on an earlier draft of this manuscript. Correspondence and requests for reprints should be sent to Stephen W. Holborn, Department of Psychology, University of Manitoba, Winnipeg, Manitoba R3T 2N2, Canada.

It is well known that precise schedule control of human operant responding is difficult to achieve using traditional schedules of reinforcement. For example, human fixed-interval (FI) performance may be characterized by a rapid constant rate or, as in most nonhumans by a lower response rate with postreinforcement pausing (e.g., Leander et al., 1968; Weiner, 1969) depending on variables such as response cost, experimental history, and instructions. Further, human responding has been shown to be insensitive to schedule differences such as FI versus fixed ratio (FR; Weiner, 1970) and to other changing consequences of responding in a variety of procedures (Ader & Tatum, 1961; De Luca & Holborn, 1985; Harzem et al., 1978; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981). The verbal capacity of the human organism is often proposed as the variable producing insensitivity in this research. For example, Matthews et al. (1977) demonstrated insensitivity to VI (variable-interval) versus VR (variable-ratio) schedules even when minimal instructions regarding the experimental task were used. Shimoff et al. (1981) considered such task instructions to be instrumental in producing schedule insensitivity.

Subsequent research has undertaken to demonstrate that verbal stimuli can control rates of responding that may minimize reinforcement on key-pressing schedules. Several investigations have attempted to create an "oppositional" interaction between a schedule of reinforcement for a motor response, such as key pressing, and a verbal stimulus specifying response rate (e.g., Catania, Matthews, & Shimoff, 1982; Hayes et al., 1986; Matthews et al., 1985). The verbal stimulus is presented either directly through verbal instruction of response rate (Hayes et al., 1986) or contingency shaped by reinforcing successive approximations to a target verbal description (Catania et al., 1982; Matthews et al., 1985). Typically, response rate has conformed to the instructed or shaped verbal description of response rate rather than to the schedule of reinforcement for key pressing.

For example, Catania et al. (1982) investigated the effects on nonverbal responding of shaped rate descriptions of nonverbal performance. In their procedure, college students' button presses produced points that were exchangeable for money on alternating VR and VI schedules. The responses were performed on separate buttons for each schedule. Every 3 min, students completed written sentences describing the way to earn points on each button. When the desired sentence completion was shaped by differentially awarding points for written descriptions of high- and low-rate pressing, pressing rates always conformed to those descriptions. This verbal control ("verbal control" here, and henceforth, indicating response-rate control by experimentally introduced verbal stimuli) occurred even when the description was in opposition to the scheduled contingency (e.g., the subject pressed slowly on the VR schedule, which provides points maximally for rapid responding, when the reinforced description specified slow responding). When students were instructed what to write in order to receive points for sentence completions, the relationship between verbal and nonverbal responding was variable. The performance description sometimes controlled, was sometimes controlled by, and was sometimes independent of the motor behavior. Matthews et al. (1985) extended the shaping aspect of their procedure to demonstrate that contingency descriptions (e.g., "Press until a random number has been reached."), as opposed to the performance descriptions used in the previous study, could control response rate. More recently, Hayes et al. (1986) demonstrated the effectiveness of experimenter-delivered instructions in controlling response rates on a multiple FR/differential reinforcement of low rates (DRL) schedule.

The cumulative results of Catania et al. (1982), Matthews et al. (1985), and Hayes et al. (1986) suggest that both shaped and instructed verbal descriptions can exert more powerful control over a motor response than do the actual contingencies of reinforcement for that response. In short, if the verbal description and the scheduled contingencies are put in opposition, the subject's behavior may conform to the verbal description rather than to the schedule.

Implicit in the above argument is the assumption that the scheduled contingencies alone would have produced response rates different from those specified by the verbal descriptions. Control by the contingencies alone must be demonstrated in order to discuss meaningfully the effects of placing verbal descriptions in opposition to the scheduled contingencies.

In this context it is useful to introduce two terms: *differential schedule control* and *discriminative schedule control,* the former pertaining under circumstances in which two (or more) schedules produce different rates of behavior and the latter pertaining to the degree that one (or more) schedules produce specific rates of behavior. In these terms, schedules that produce specific rates of responding may be discriminative of differential rates of responding or they may be discriminative of nondifferential rates of responding (i.e., they produce the same specific rate of responding). The response rate for which a schedule is discriminative presumably depends on the rate that will maximize the density of reinforcers on that schedule. Thus, using the schedules employed by Hayes et al. (1986) as examples, the establishment of low-rate responding on a DRL schedule and high-rate responding on an FR schedule would indicate appropriate discriminative control, appropriate to the extent that control is a function of discriminating the response rate that maximizes the rate at which reinforcers are delivered. In the case of Matthews et al. (1985) and Catania et al. (1982), discriminative control by the schedules should produce high-rate responding on the VR schedule (for which reinforcer density is a function of response rate) and relatively lower rate responding on the VI schedule (for which the relationship between response rate and reinforcer density holds true for a limited range of low rates). In all cases mentioned above, discriminative control would be expected to produce differential response rates between the two schedules employed in each study (i.e., differential schedule control).

Scrutiny of the Matthews et al. (1985) and Catania et al. (1982) data reveals that the contingencies used in these studies did not differentially control behavior in the absence of verbal descriptions. As Catania et al. (1982, p. 236) note, during periods before a verbal description had been shaped, response rates were nearly identical on the two schedules, differing only after verbal stimuli had been introduced. Nor is there evidence for clear discriminative control of response rate (in the absence of differential control), because, for the majority of subjects, response rates on both schedules were in a state of change when verbal stimuli were introduced.

Similarly, in Experiment 1 of Hayes et al. (1986), subjects receiving no specific instructions about how to respond on the schedules made extensive contact with only one of the two types of programmed consequences; that is, subjects earned points primarily on either the DRL or the FR schedule, but not on both. Response rates on the two schedules reflected this contact, being similar and high for 2 subjects (contacting only the FR schedule), similar and low for 1 subject (contacting only the DRL schedule), and dissimilar for 1 subject (high on FR, low on DRL). Even the subject with dissimilar response rates on the two schedules earned points primarily on only one schedule (FR). Here again, when instructions are used to alter response rate, it is uncertain how powerful the schedule control would be in the absence of the instructions (indeed, the evidence suggests poor discrimintative control of response rate by one schedule, at least under these multiple schedule conditions). Only after response-rate instructions brought about contact with both schedules (Experiment 2) was discriminative (and differential) schedule control of response rate demonstrated. Our suggestion, then, is that in all of the previously discussed manipulations (Catania et al., 1982; Hayes et al., 1986; Matthews et al., 1985), poor discriminative schedule control promoted the demonstrated verbal control of response rate. Although previous studies clearly demonstrate human responsiveness to verbal control of response rate, they do so under circumscribed conditions: conditions of poor discriminative schedule control. This suggestion is in accordance with Cerutti's (1989, p. 265) comment that insensitivity to collateral consequences (i.e., control by verbal stimuli) is likely when those consequences are weak (i.e., under conditions of poor discriminative schedule control), but not when they are strong.

The present study attempted to extend the literature on interacting verbal and nonverbal influences on human responding by opposing verbal descriptions of response rate to specially designed schedules with demonstrated discriminative control of response rate. The present procedures were similar to those employed by Matthews et al. (1985) except for alterations designed to increase the power of the experimental demonstration.

First, and most important, the present study sought to increase discriminative control by the schedule contingencies and to demonstrate this control prior to the introduction of verbal stimuli. Consideration of the difficulties typically associated with producing precise schedule-controlled response rates in humans led us to use novel schedules of reinforcement to achieve precise control. The programmed contingencies on the subjects' motor behavior awarded a variable number of points at regular intervals depending on the number of responses emitted during an individual interval (i.e., depending on the response rate per interval). Unlike traditional schedules, which typically provide reinforcement on an all-or-none basis, the schedules were programmed to provide a maximum number of points for a specific range of rates while providing progressively fewer points for response rates increasingly dissimilar from that range. Thus, changes in response rate toward, or away from, the range of rates receiving the maximum number of points resulted in (theoretically) highly discriminable changes in the number of points received following each interval. The schedules employed in this research also deviate from the typical practice of providing reinforcement conditional on single interresponse times by providing points dependent upon the number of responses per fixed unit of time. Thus, an alternative schedule (ours) providing points maximally for a slow rate of responding would satisfy the less frequently cited Ferster and Skinner (1957, p. 459) definition of DRL, wherein reinforcement is not continuous and based on single interresponse times but rather depends on the emission of *N* or fewer responses within a specified time interval. In the terminology of Martin and Pear (1988, p. 107) this schedule is termed "interval DRL." Alternatively, a schedule providing points maximally for very rapid responding would function as a differential reinforcement of high rate (DRH) schedule similar to schedules used by Burnstein and Wolff (1964), in which reinforcement depends on the emission of greater than *N* responses within a specified time interval. Extending the DRL terminology of Martin and Pear (1988) to this type of schedule produces the label "interval DRH." Adjustment of this maximally point-awarded (MaxPA) response-rate range can produce schedules providing a maximum number of points for very rapid responding, very slow responding, or a variety of rates between these extremes. Thus, these schedules have the advantage of being easily adjusted in terms of similarity, both to each other and to the verbal descriptions they oppose. Baseline measures were taken to demonstrate control by the schedules in the absence of verbal performance descriptions. Thus, verbal descriptions were superimposed on baselines whose schedule-controlled terminal rates had been demonstrated empirically.

Second, performance descriptions rather than contingency descriptions were used, because they require a less specialized vocabulary and have been found to be more consistently related to motor performance (Matthews et al., 1985). Third, verbal response descriptions were standardized by providing subjects with a choice among five response-speed descriptions (very slowly, slowly, medium, fast, very fast). This permitted precise quantification of the disparity between the chosen verbal description and the MaxPA response-rate range and also provided a variety of verbal descriptions, more or less opposing the active schedule, that could receive maximum points. Fourth, verbal descriptions were chosen after each key presentation rather than, as in Matthews et al. (1985), after each two-key cycle. This change produced closer contiguity between schedule experience and choice of verbal description.

Experiment 1 first attempted to demonstrate precise control of response rate using specially designed schedules. Subsequently, the effects of gradually opposing verbal descriptions to the schedule contingencies, and the effects of gradually opposing the schedule contingencies to verbal descriptions, were investigated. It was expected that both procedures would result in lower verbal control of response rate than in previous research because of increased discriminative schedule control.

GENERAL METHOD

Subjects

Eight female and 3 male University of Manitoba undergraduates between 18 and 35 years of age participated as subjects as an option in satisfying introductory psychology course requirements. The subject selection procedures paralleled those of Matthews et al. (1985).

Apparatus

The study was conducted in a research room (4 m by 4 m) in the psychology building at the University of Manitoba. The room contained a desk for the experimental apparatus and a chair. A subject, when seated in the chair, faced the experimental apparatus, which consisted of a Macintosh Plus® microcomputer (screen size: 19 cm by 15 cm) and a modified Macintosh keypad. Two of the keypad keys (the A and the K) were labeled clearly as the response keys using masking-tape squares that displayed the corresponding letter in large black print. Presses on these keys fulfilled the requirements of the schedule contingencies. The computer indicated which key was operational by presenting a printed A or K, corresponding to the operational key, 3 cm from the side of the screen nearest that key (left side for A, right side for K) and 5 cm from the bottom of the screen. The computer was programmed to present all instructions to subjects, to calculate the rate of responding on each schedule, to record subjects' verbal descriptions, and to dispense points. Points were exchangeable after each session for tickets in an experimenter-run lottery. To the right of the computer screen was a set of printed instructions on a cardboard backing. For all groups, and during all phases, these instructions duplicated those presented on the computer monitor prior to the experimental session.

General Procedure

All subjects in all phases received a single experimental session each day.

Instructions. In the research room, each subject was seated facing the computer and a set of instructions. The experimenter began the initial session with the following instructions:

> Everything that occurs in this experiment is between you and the computer. The computer will tell you everything you need to know about the experiment in the instructions which you are about to read. As you can see, the first instructions are already on the screen. When you reach the bottom of a page press any key and further instructions will appear. The computer will also tell you how to begin the session when you have finished reading the instructions. Please notice that the instructions are also listed to the right of the computer screen. If you want to review any of the instructions you can read them there. The computer will tell you when the session is complete. Please open the door when the computer indicates that the session is over. Are there any questions? Please wait until I have left the room before you begin.

The experimental instructions were similar across groups and were identical within groups across phases. The following instructions include all groups and all phases:

> Purpose of Study: The purpose of the present study is to investigate how people learn to perform tasks.
>
> Experimental Task: Your task is to earn as many points as you can during the experimental session.
>
> General Instructions: During the experimental session you can earn points by pressing the two keys labeled A and K. Depending on the rate at which you press the keys, the computer will add a certain number of points to your point total at regular intervals. This point total will be displayed at the top of the screen.
>
> Only one key will be available for earning points at a time. When an A appears on the screen you can earn points by pressing the key on the keyboard that is labeled with an A. When a K appears on the screen you can earn points by pressing the key on the keyboard that is labeled with a K. The computer will add points to your point total at regular intervals.

The following paragraph was included in phases requiring a sentence completion:

> There is a second way in which you can earn points. After you have had a chance to earn points by pressing one of the keys, the computer will ask you to describe how you should press that key to receive the most points. There will be five possible ways described on the screen. You are to select one of the five possibilities. The computer will show you how many points you earn for your choice. You can earn a maximum of 60 [180 for "random" subjects in Experiment 2] points for your choice.

The instructions continued as follows for all subjects:

> Token System: The total number of points you have earned will be displayed at the top of the screen until the end of the session. The points that you earn in this experiment will be exchangeable for lottery tickets at the end of the session. Each ticket costs 200 points [600 for "random" subjects in Experiment 2]. The more lottery tickets you can buy, the more likely that you will be the winner of the lottery. Two tickets will be drawn each week, with a prize of $30 awarded for the first ticket drawn and a prize of $20 for the second ticket. There are only a few other people in this experiment so if you are all about equal at earning points you will have a good chance of winning either the first or the second prize. If you do especially well, your chances of winning will be improved.
>
> The computer will stop automatically when the session is complete. When the session is complete the experimenter will have you fill out a brief questionnaire. If you cannot remember something about the instructions, they are listed to the right of the computer.
>
> The next time you hit a key the session will begin.

The first key press following the instructions started the experimental session, during which points were available to subjects for two types of responses. First, schedule points were available for presses to the A and K keys of the computer keypad. Second, in certain phases, verbal description points were available for completing sentence stems describing the optimal key-pressing rate.

Key pressing. The first key press following the instructions started the experimental session. An A was presented on the left side of the screen, near the A key. This stimulus was presented for 1 min 6 s, during which time presses on the A key earned points. Following the expiration of the A interval, the K stimulus was presented on the right side of the screen near the K key for 1 min 6 s, during which time presses on the K key earned points. The A was then presented again, beginning a new 2-min 12-s cycle in which each key was presented once. Each session included seven such cycles, with the A key always presented first, for a total session time of approximately 15 min 24 s. Points were awarded every 5.5 s for a total of 12 reinforcement intervals per key presentation.

Based on the response rates obtained by other researchers and pilot work, a five-level response distribution was calculated such that specific response-rate ranges could be reinforced. For example, based on Catania et al. (1982) and Matthews et al. (1985), a response-rate range of 11 to 15 responses per 5.5-s interval appeared to be a "medium" rate of key pressing for the typical undergraduate student. Based on maximum observed rates in these studies of about 35 responses per 5.5 s and considering that responding can reach a minimum of one response per 5.5 s and still be considered "responding," the following categories were established: *very slowly*—1 to 5 responses per 5.5-s interval; *slowly*—6 to 10 responses per interval; *medium*—11 to 15 responses per interval; *fast*—16 to 20 responses per interval; and *very fast*—more than 20 responses per interval.

Points were established for each of these response-rate ranges. These points, which were exchangeable for lottery tickets at the end of each session, were added every 5.5 s to one of two counters located 2.5 cm from the top of the screen. One counter, positioned 4 cm from the left side of the screen, was labeled "Points for A" and displayed all points earned on Key A. The other counter, positioned 4 cm from the right side of the screen, was labeled "Points for K" and displayed all points earned on Key K. Point distributions could be varied such that particular response rates were awarded maximum points (MaxPA response-rate ranges). For example, for a medium response rate, the point distribution for the five response-rate ranges was 2, 3, 5, 3, 2, listed from very slow to very fast, respectively. In other words, depending on the rate of responding generated by the subject during each 5.5-s period, the points received at the end of that 5.5-s period varied from 2 to 5 depending on the range into which response rate fell. Maximum points (5) were delivered for a response rate that fell in the medium range. In contrast, the distribution of point values designed to generate very fast responding was 1, 2, 3, 4, 5; the distribution of point values designed to generate fast responding was 1, 2, 3, 5, 4; the distribution of point values designed to generate slow responding was 4, 5, 3, 2, 1; and the distribution of point values designed to generate very slow responding was 5, 4, 3, 2, 1. The point values were chosen so that regardless of the MaxPA response-rate range, points would decrease as response rate fell further outside that range, while total points available would remain constant. The exceptional cases were applied to the two groups of subjects in Experiment 2. For subjects receiving nondifferential reinforcement of responding, points were distributed equally across response-rate ranges (e.g., 13, 13, 13, 13, 13). For random subjects, the computer awarded point values with particular probabilities irrespective of response rate. Every 5.5 s the computer added the appropriate number of points to individual point counters for each key. Presses on the key not corresponding to the symbol on the screen had no programmed consequences. A complete absence of responding during an interval did not change the counter.

Verbal descriptions. During phases requiring verbal descriptions of pressing rates, a sentence stem was presented on the computer screen following the completion of each 1-min 6-s cycle. This produced seven verbal descriptions of the best pressing rate for each key during a session. The sentence stem following the activation of Key A said: "The best way to earn points on Key A is:" The sentence stem following the activation of Key K said: "The best way to earn points on Key K is:" Each stem was followed by five choices: "press very slowly," "press slowly," "press at a medium rate," "press fast," and "press very fast," numbered from 1 to 5, respectively. The instruction, "Press the number corresponding to your selection," preceded the stems. After the subject had selected a number corresponding to his or her choice from the numerical row at the top of the keypad, the computer displayed "You received X points out of a possible X points for that response." The computer then instructed the subject to press any key to continue the session. That press initiated the next key-pressing segment of the session and added the points for the verbal description to the appropriate key counter.

Points were designated for each verbal description such that a selected verbal description would earn the maximum number of points. For the present paper, the point values accompanying the verbal descriptions will be listed form "press very slowly" to "press very fast," respectively. Thus, a 60, 48, 36, 24, 12 verbal description distribution maximally reinforces a description of "press very slowly." Points for verbal descriptions usually were chosen to equalize the number of points potentially available for actual key pressing and for verbal descriptions of key pressing (the one exception is mentioned under its specific procedure). This involved multiplying the schedule points available by 12 to calculate verbal description points, because verbal description points were earned once per key presentation, and schedule points were earned 12 times per key presentation.

Stability criteria. Two stability criteria were employed in the present study. First, the percentage of 5.5-s interval response rates within the MaxPA range had to equal or exceed 90% for both keys in three consecutive sessions. Second, in phases requiring a verbal description, verbal description values had to equal or exceed 25 for each key in the same three sessions. The verbal response choices were converted to point values ranging from 0 to 4 depending on how close the choice was to the MaxPA verbal description, for a maximum of 28 possible points earnable on each key in each session (see Results for an elaboration on this conversion). In a few select instances, subjects were given additional sessions beyond the point at which stability was achieved because either (a) stability was achieved immediately prior to a weekend or (b) the subject missed two or more consecutive sessions due to illness. In both cases we contrived to switch phases over sessions conducted on consecutive days.

EXPERIMENT 1

Experiment 1 sought, first, to demonstrate precise discriminative control of response rate using our specially designed schedules. This demonstration was designed to ensure that the subsequently introduced verbal descriptions were imposed on a baseline of known response rate, thus allowing the opposition of these verbal descriptions to the established response rate. The effects of gradually opposing the schedule contingencies to the verbal descriptions (Experiment 1a) and the effects of gradually opposing the verbal descriptions to the schedule contingencies (Experiment 1b) were both investigated. It was expected that (a) the schedules used in the present research would demonstrate precise discriminative control over response rate and (b) that both procedures (Experiment 1a and 1b) would produce less verbal control of response rate than did previous research due to increased discriminative schedule control.

METHOD

Subjects

Three female students and 1 male student served as participants in Experiment 1.

Procedure

Experiment 1a. Subjects 1 and 2 experienced a 2, 3, 5, 3, 2 schedule of reinforcement for both response keys at the outset of the study. The purpose of this manipulation was to establish key pressing at a medium rate (as defined earlier). When the stability criterion for the percentage of interval response rates falling within the MaxPA range was reached, point awards for sentence stem completion were interposed between key-pressing segments. The point distribution for A descriptors was 60, 48, 36, 24, 12. The point distribution for K descriptors was 12, 24, 36, 48, 60. Thus, for Key A, descriptors of "press very slowly" received maximum points, whereas for Key K, descriptors of "press very fast" received maximum points. The prior schedule of reinforcement was maintained to reinforce maximally a medium rate on both keys. When stability criteria for both the percentage of interval rates within the MaxPA range and for verbal descriptions were reached, the contingencies on response rate were changed gradually to oppose the MaxPA verbal description. Satisfaction of both stability criteria was required for both keys prior to each schedule change. Contingencies on Key A were changed first to 1, 2, 3, 5, 4, maximally reinforcing a fast rate, and then to 1, 2, 3, 4, 5, maximally reinforcing a very fast

Table 1

Points delivered for motor and verbal responses during each phase of Experiment 1a.

	Points for response rate									
	Key A					Key K				
	Very slowly	Slowly	Med	Fast	Very fast	Very slowly	Slowly	Med	Fast	Very fast
1st phase	2	3	5	3	2	2	3	5	3	2
2nd phase	2	3	5	3	2	2	3	5	3	2
3rd phase	1	2	3	5	4	4	5	3	2	1
4th phase	1	2	3	4	5	5	4	3	2	1

rate. Contingencies on Key K were changed first to 4, 5, 3, 2, 1, maximally reinforcing a slow rate, and then to 5, 4, 3, 2, 1, maximally reinforcing a very slow rate. The points for verbal descriptions remained unchanged throughout these phases. Table 1 summarizes the programmed consequences for both response rates and verbal selections in Experiment 1a.

Experiment 1b. Subjects 3 and 4 experienced a 2, 3, 5, 3, 2 (medium rate) schedule of reinforcement for both response keys at the outset of the study. Following the achievement of criterion percentages of interval response rates within the MaxPA range for both keys, the response-rate contingencies were changed to 5, 4, 3, 2, 1 for Key A, maximally awarding points for a very slow rate, and to 1, 2, 3, 4, 5 for Key K, maximally awarding points for a very fast rate. Following the achievement of criterion percentages of interval response rates within the MaxPA range for both keys, verbal descriptions were introduced. The MaxPA verbal description for Keys A and K was moved gradually from a descriptor corresponding with, to one opposed to, the MaxPA pressing rate. Verbal description point distributions of 60, 48, 36, 24, 12 (maximum points for selecting "press very slowly"); 48, 60, 36, 24, 12; 24, 36, 60, 36, 24; 12, 24, 36, 60, 48; and 12, 24, 36, 48, 60 (maximum points for selecting "press very fast") were applied successively to Key A, whereas verbal description point distributions of 12, 24, 36, 48, 60 (maximum points for selecting "press very fast"); 12, 24, 36, 60, 48; 24, 36, 60, 36, 24; 48, 60, 36, 24, 12; 60, 48, 36, 24, 12 (maximum points for selecting "press very slowly") were applied successively to Key K. The response-rate contingencies remained unchanged for the two keys. The achievement of stability criteria both for the percentage of interval response rates falling within the MaxPA range and for verbal descriptions was required for both keys prior to movement to the next pair of point distributions. Consequently, shifts in point distribution occurred simultaneously on the two response keys. Table 2 summarizes the programmed consequences for both response rates and verbal selections in Experiment 1b.

Table 2

Points delivered for motor and verbal responses during each phase of Experiment 1b.

	Points for response rate									
	Key A					Key K				
	Very slowly	Slowly	Med	Fast	Very fast	Very slowly	Slowly	Med	Fast	Very fast
1st phase	2	3	5	3	2	2	3	5	3	2
2nd phase	5	4	3	2	1	1	2	3	4	5
3rd phase	5	4	3	2	1	1	2	3	4	5
4th phase	5	4	3	2	1	1	2	3	4	5
5th phase	5	4	3	2	1	1	2	3	4	5
6th phase	5	4	3	2	1	1	2	3	4	5
7th phase	5	4	3	2	1	1	2	3	4	5

Table 1 (*Continued*)

Points for verbal selections									
Key A					Key K				
Very slowly	Slowly	Med	Fast	Very fast	Very slowly	Slowly	Med	Fast	Very fast
—	—	—	—	—	—	—	—	—	—
60	48	36	24	12	12	24	36	48	60
60	48	36	24	12	12	24	36	48	60
60	48	36	24	12	12	24	36	48	60

Results

The dependent measures were (a) the mean sessional response rate per 5.5-s feedback interval for Keys A and K, (b) the percentage of 5.5-s intervals in which the response rate fell within the MaxPA range, and (c) the number of points earned for verbal descriptions on Keys A and K. The number of points for verbal descriptions was calculated by summing the seven responses per session describing each key using the following formula: The point values 12, 24, 36, 48, 60 for verbal descriptions corresponded to 0, 1, 2, 3, 4 points, respectively. Consequently, the number of points earned for sentence completions describing a given key during any session ranged from 0 for descriptions opposing the MaxPA description to 28 for descriptions consistently matching the MaxPA description.

Figures 1, 2, 3, and 4 show the mean sessional response rate, percentages of interval response rates within the MaxPA range, and the total verbal description points for Keys A and K across sessions for Subjects 1, 2, 3, and 4, respectively. In each figure, mean sessional response rate is indicated by open (Key A) and filled (Key K) squares. The percentages of individual intervals in which response rates fell within the MaxPA range are indicated by the numbers closest to the data points; verbal description points are indicated by the numbers furthest from the data points. In terms of key-pressing contingencies, all subjects showed mean sessional rates for both keys falling within the MaxPA response-rate ranges in virtually all sessions of all phases. The single exception was Subject 4 (Figure 4), whose mean sessional response rates took several sessions to consistently fall within the MaxPA range in the first two phases. For Subjects 1 (Figure 1) and 2 (Figure 2), mean sessional response rates remained within the MaxPA ranges across sessions, despite two shifts in the MaxPA. Percentages of interval rates within the MaxPA ranges were almost consistently above criterion, with the exception of Sessions 1 through 5 and 9 through 14 for Subject 4 and the first session of new phases for Subjects 1 and 2. Differential schedule control of response rate was demonstrated clearly for all subjects. In

Table 2 (*Continued*)

Points for verbal selections									
Key A					Key K				
Very slowly	Slowly	Med	Fast	Very fast	Very slowly	Slowly	Med	Fast	Very fast
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
60	48	36	24	12	12	24	36	48	60
48	60	36	24	12	12	24	36	60	48
24	36	60	36	24	24	36	60	36	24
12	24	36	60	48	48	60	36	24	12
12	24	36	48	60	60	48	36	24	12

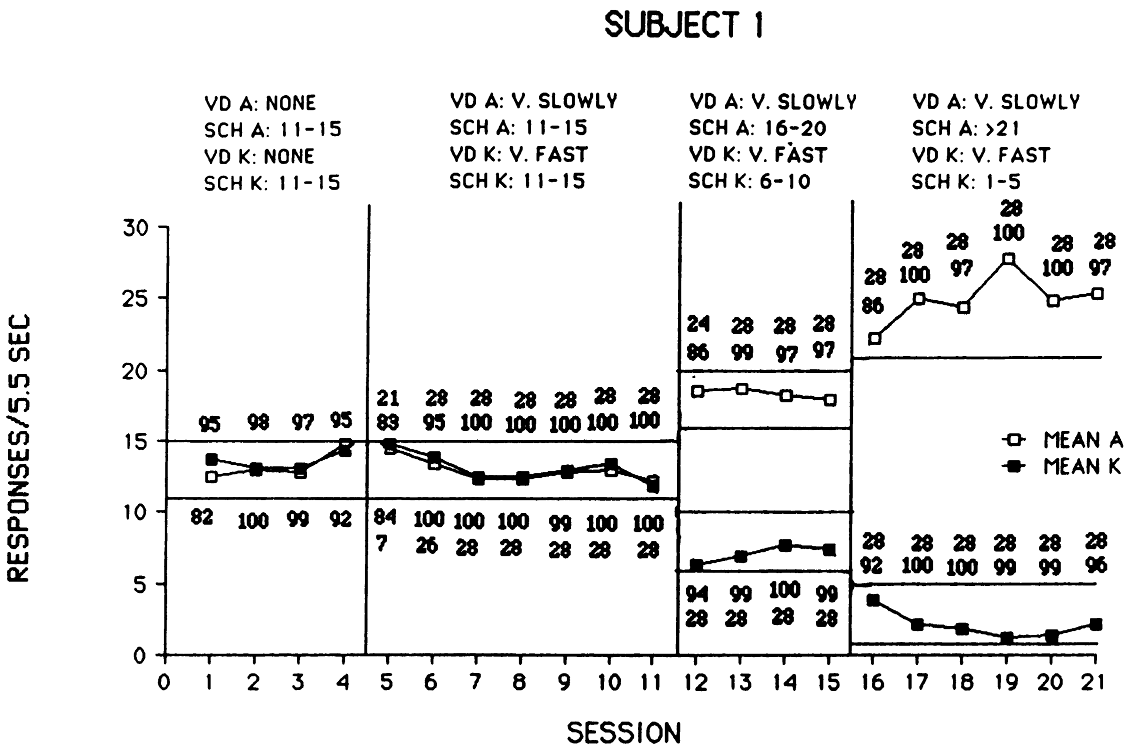

Fig. 1. Mean sessional response rates on Keys A and K (open and filled squares, respectively), percentage of 5.5-s intervals in sessions in which response rate fell inside the maximally reinforced range (numbers nearest the data points), and number of verbal description points earned in the session (numbers furthest from the data points) for Subject 1. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key (A and K). Horizontal lines indicate the response-rate ranges for which the maximum numbers of points were delivered by the operative schedule.

terms of verbal descriptions, the MaxPA verbal description was almost always chosen, except in the session following a phase change. Choice of verbal description had no effect on key-pressing rate. Despite lack of correspondence between verbal description and schedule contingency experienced by all subjects, pressing rates conformed to the active schedule in all sessions.

Discussion

The mean sessional response rates and the percentage of interval rates within the MaxPA range generated in Experiment 1 clearly show that the schedules used in the present study exert discriminative control over response rate. Unlike past research (Hayes et al., 1986; Matthews et al., 1985), the present study demonstrated schedule control before introducing the verbal description task. Thus, in the present research, reinforced verbal descriptions were superimposed on effectively discriminative and differential schedule contingencies, making statements about opposition meaningful.

Results of Experiment 1 clearly indicate that the contingencies on verbal descriptions and on key pressing controlled their respective classes of behavior without mutual interference. Pressing rates conformed to the schedule requirements regardless of the subject's verbal descriptions of how to perform to earn the most points. Similarly, MaxPA verbal descriptions were chosen regardless of their accuracy in describing the schedule requirements. These results contrast with those of Catania et al. (1982), Matthews et al. (1985), and Hayes et al. (1986) in which pressing rate was demonstrated to correspond to the verbal description or instruction, regardless of the pro-

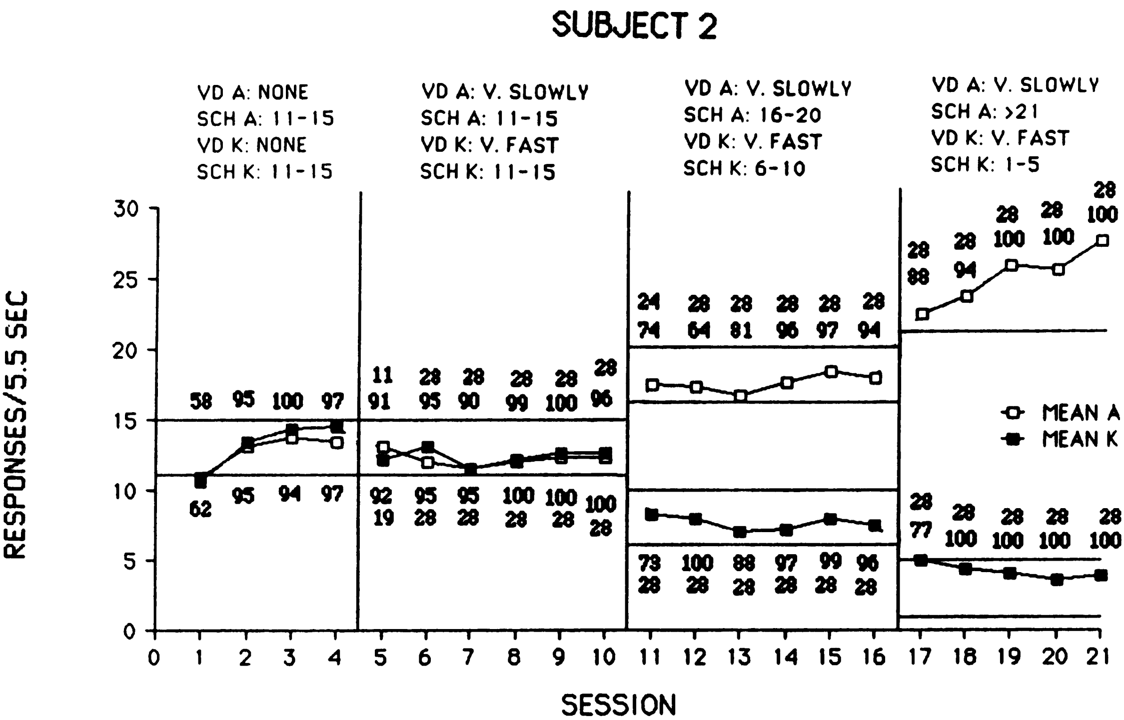

Fig. 2. Mean sessional response rates on Keys A and K (open and filled squares, respectively), percentage of 5.5-s intervals in sessions in which response rate fell inside the maximally reinforced range (numbers nearest the data points), and number of verbal description points earned in the session (numbers furthest from the data points) for Subject 2. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key (A and K). Horizontal lines indicate the response-rate ranges for which the maximum numbers of points were delivered by the operative schedule.

grammed schedule for key-pressing behavior. As expected, there was no evidence of verbal control over pressing rate in the present research, presumably (as we might conclude from the aforementioned statement by Cerutti, 1989, p. 265) due to the powerful discriminative control by the schedules employed.

There are two major reasons for the apparent strength of discriminative control of response rate by the schedules in the present research. First, because of the design of the schedule, with points for schedule performance during an interval being presented in evaluable units, subjects can easily identify performances that do not correspond to schedule contingencies (provided there is sufficient variability in response rate to sample other programmed response-rate ranges). Because subjects can easily discriminate performance outside the MaxPA range, this type of reinforcement schedule tends to increase discriminative control by the schedule. Such discriminative control appears to have been lacking in past research. Second, a history of contingency control of pressing rate is established in both procedures before points are provided for verbal performance descriptions. This history of schedule control serves to increase discriminative control of response rate by the schedule. Studies described above did not establish schedule control prior to instituting verbal control, both contingencies being implemented simultaneously.

In summary, Experiment 1 demonstrated conditions under which verbal descriptions of response rate do not control response rate in the presence of opposing schedules. These data differ from previous results (Catania et al., 1982; Hayes et al., 1986; Matthews et al., 1985) that demonstrated verbal control of response rate. The relative amount of verbal versus schedule control over response rate pre-

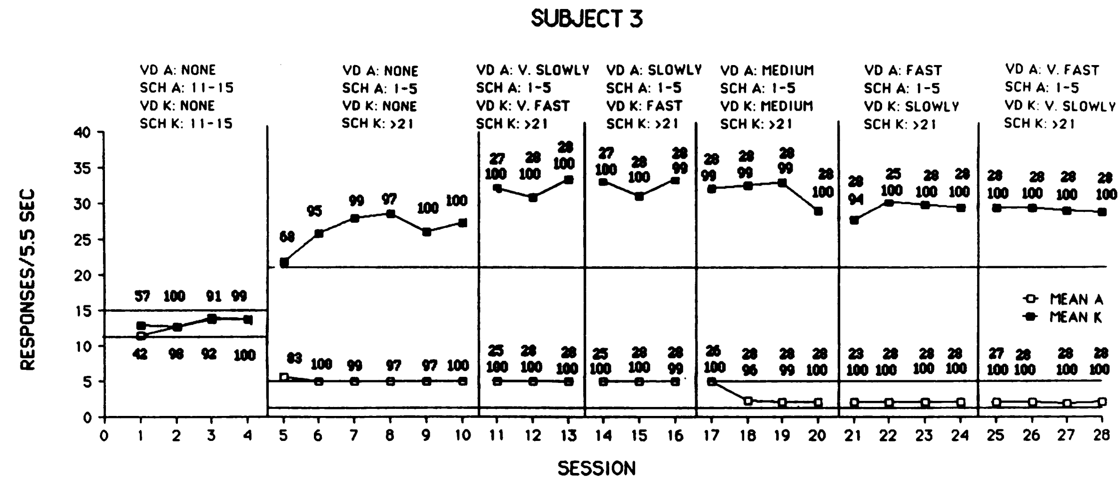

Fig. 3. Mean sessional response rates on Keys A and K (open and filled squares, respectively), percentage of 5.5-s intervals in sessions in which response rate fell inside the maximally reinforced range (numbers nearest the data points), and number of verbal description points earned in the session (numbers furthest from the data points) for Subject 3. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key (A and K). Horizontal lines indicate the response-rate ranges for which the maximum numbers of points were delivered by the operative schedule.

sumably depends on the relative strength of discriminative control by each, with discriminative control by the schedule enhanced in the present research through the nature of the schedule and by prior schedule exposure.

EXPERIMENT 2

If the lack of verbal control of response rate seen in Experiment 1 was due to the precise discriminative control by the schedules, then, presumably, a decrease in discriminative control by the schedules would increase verbal control of response rate. Experiment 2 sought to facilitate discriminative control by the verbal description through procedural changes designed to decrease the level of discriminative control by the schedules. First, this procedure eliminated the history of schedule control over pressing rate prior to the introduction of verbal performance descriptions. To accomplish this end, subjects were given the opportunity to make verbal descriptions from the outset of the experiment. Second, Experiment 2 sought to eliminate the obvious contingent relationship between response rate and points earned by awarding points nondifferentially with respect to response rate, thus decreasing the chances that schedule contact would prevent discriminative control by the verbal description.

Two distinct methods were investigated. Experiment 2a used a schedule of reinforcement that awarded the same number of key-pressing points regardless of pressing rate (provided at least one response occurred in the interval). As in Experiment 1, verbal descriptions were shaped by the points provided for each choice. Experiment 2b was designed to anticipate two possible weaknesses of Experiment 2a with respect to establishing verbal control over key-pressing rate. First, Experiment 2b used a schedule of reinforcement that awarded a randomly determined point value regardless of pressing rate (provided, again, that at least one response occurred in the interval). It was thought that the nondifferential contingency operative in the first procedure might be too easily detectable considering that the same point value would be added to the point counter following each interval in which a response occurred. Second, verbal descriptions were "instructed," rather than shaped, by including in the preexperimental instructions a specification of the point values associated with each verbal choice. This was designed to increase the chances that the desired verbal description would be established after a minimum of schedule exposure. Despite Catania et al.'s (1982) demonstration that the effects of instructions may be variable, Hayes et al.'s (1986) demonstration of consistent instructional effects under certain conditions and

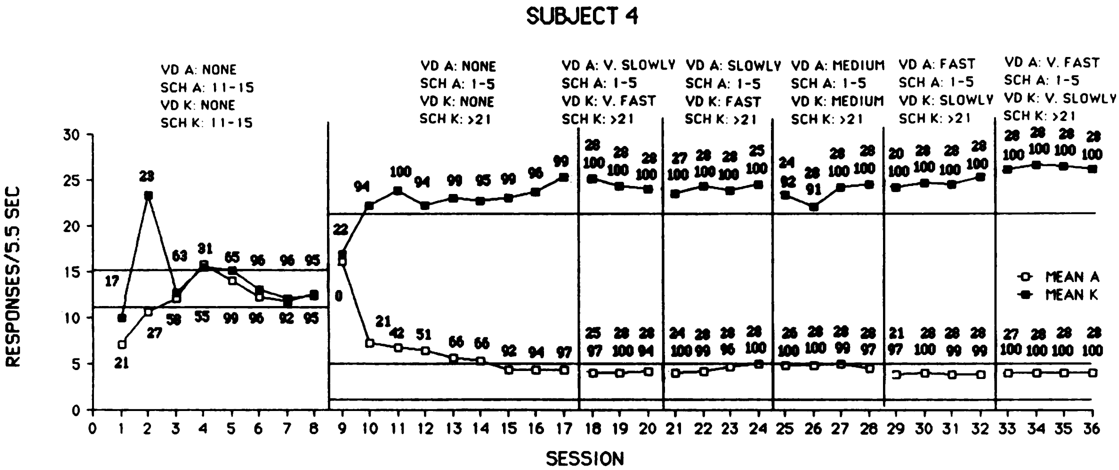

Fig. 4. Mean sessional response rates on Keys A and K (open and filled squares, respectively), percentage of 5.5-s intervals in sessions in which response rate fell inside the maximally reinforced range (numbers nearest the data points), and number of verbal description points earned in the session (numbers furthest from the data points) for Subject 4. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key (A and K). Horizontal lines indicate the response-rate ranges for which the maximum numbers of points were delivered by the operative schedule.

our need for immediate opposition of verbal and nonverbal sources of response-rate control prompted us to use instructions. It was expected that both procedures (Experiment 2a and 2b) would decrease the discriminative control of the schedules sufficiently to allow verbal control to occur.

METHOD

Subjects

Five female and 2 male students served as participants in Experiment 2.

Procedure

The second experiment contained two similar procedures, each involving one phase.

Experiment 2a. Subjects 5, 6, 7, and 8 experienced a condition in which 13 points were awarded every feedback interval, regardless of the number of presses emitted during that interval (for responses >0). The response-rate point distribution was thus 13, 13, 13, 13, 13. The number 13 was selected over the single digit point values employed in Experiment 1 to hinder subjects in discriminating that the same number was added to the cumulative counter following each feedback interval. The verbal description point distributions were 60, 48, 36, 24, 12 for Key A and 12, 24, 36, 48, 60 for Key K, maximally reinforcing a description of "press very slowly" for Key A and "press very fast" for Key K. Data were collected from each subject until mean sessional response rates for each key were stable (three consecutive sessions with a range of fewer than three responses per 5.5 s) or until subjects had fulfilled their obligation for experimental credit.

Experiment 2b. Subjects 9, 10, and 11 experienced a condition in which the computer awarded points following each 5.5-s interval with the following probabilities: 11 points, .05; 12 points, .10; 13 points, .10; 14 points, .15; 15 points, .20; 16 points, .15; 17 points, .10; 18 points, .10; 19 points, .05. Consequently, the number of points awarded was independent of the number of responses emitted (for responses >0). As in Experiment 2a, two-digit numbers were employed to decrease the discriminability of the independence between response rate and point awards. Verbal description point distributions were 36, 72, 108, 144, 180 for Key A and 180, 144, 108, 72, 36 for Key K, maximally reinforcing a verbal description of "press very fast" for Key A and "press very slowly" for Key K. Correcting an oversight of Experiment 2a, the verbal description point values were chosen to balance the number of points available on the schedule for key pressing. The procedure for this group differed from that of other groups in that the verbal descriptions and their associated point values were included in the presession instructions immediately prior to the paragraph beginning "The computer will stop . . ." as well as in the printed instructions to the right of the computer. These additional instructions read:

> The following point values will be given for your choices.
>
> The best way to earn points on Key A is:
>
> | | |
> |---|---|
> | 1. Press very slowly | 36 pts |
> | 2. Press slowly | 72 pts |
> | 3. Press at a medium rate | 108 pts |
> | 4. Press fast | 144 pts |
> | 5. Press very fast | 180 pts |
>
> The best way to earn points on Key K is:
>
> | | |
> |---|---|
> | 1. Press very slowly | 180 pts |
> | 2. Press slowly | 144 pts |
> | 3. Press at a medium rate | 108 pts |
> | 4. Press fast | 72 pts |
> | 5. Press very fast | 36 pts |

Data were collected until mean sessional response rates for each key were stable (three consecutive sessions with a range of fewer than three responses per 5.5 s) or until subjects had fulfilled their obligation for experimental credit.

Results

The dependent measures were identical to those of Experiment 1, except that, due to the nondifferential nature of the schedules in Experiment 2, percentages of intervals in which response rate fell within a MaxPA range could not be calculated. Figures 5 and 6 show the mean sessional response rate and the total verbal description points for Keys A and K across sessions for Subjects 5 through 11. Results from both procedures can be grouped into three general categories.

The first category includes Subjects 5, 6, 7, and 9 and is shown in Figure 5. For these subjects, the choice of verbal description affected response rate transiently. Inspection of Figure 5 reveals higher mean sessional response rates for keys described as "press very fast" relative to keys described as "press very slowly," with a decrease in this difference across sessions. The latency to consistent choice of the MaxPA verbal description and the duration of this choice's effect on response rate varied across subjects. For Subjects 5, 6, and 9 (Subject 9 having the advantage of direct instructions), the MaxPA verbal description was consistently chosen within the first three sessions, whereas for Subject 7 consistent selection did not occur until Session 7. Control of response rate by the MaxPA verbal description choice appears to occur in Sessions 2 and 3 for Subject 5, in Sessions 2 through 4 for Subject 6, in Sessions 3 through 8 for Subject 7, and in Sessions 2 through 4 for Subject 9. For Subjects 5, 7, and 9, the terminal response rates for both keys were virtually identical and very low (approximately one response per interval). Apparently, differential control by the verbal descriptions was transient, with the schedule competing successfully for control of response rate in later sessions. By the final sessions, response rate was maximally efficient with respect to earning points on the schedule (one response per interval being the most efficient).

The second category, shown in Figure 6, includes Subjects 8 and 10. Although the MaxPA verbal descriptions were consistently chosen by Session 2 for both subjects, response rates on the two keys were virtually identical across all sessions. Both subjects exhibited initial variability in the response rate on both keys but demonstrated schedule-efficient responding on both during later sessions. Thus, differential control by the verbal descriptions was absent in all sessions, with evidence of control by the nondifferential schedules (i.e., a mean of about one response per interval in later sessions).

The third category includes only Subject 11 and is also shown in Figure 6. The MaxPA verbal description was consistently chosen by this subject during all sessions. Inspection reveals consistently higher mean sessional response rates on Key A than on Key K during all sessions, indicating strong differential control by the verbal descriptions. In addition, response-rate differences between keys were greater than the transient differences shown by Subjects 5, 6, 7, and 9.

Discussion

Experiment 2 indicates that the extent of verbal control over key-pressing rate is variable when either of two nondifferential reinforcement schedules is used. Verbal control over response rate may persist over long periods of time (Subject 11), may appear transiently (Subjects 5, 6, 7, and 9), or may be absent (Subjects 8 and 10).

It is important to note that the rate of press-

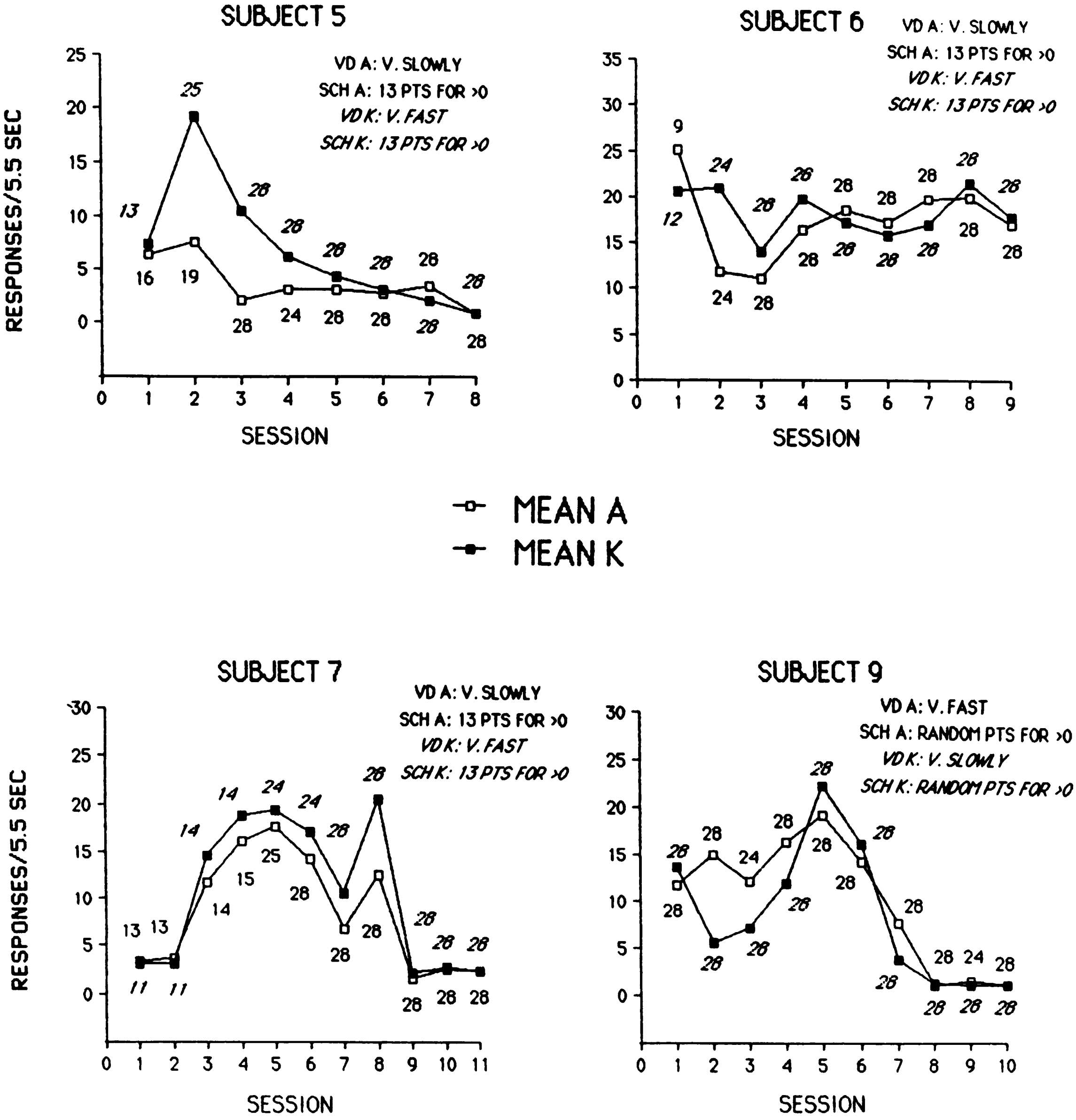

Fig. 5. Mean sessional response rates on Keys A and K (open and filled squares, respectively) and number of verbal description points earned in sessions for subjects for whom choice of verbal description transiently affected response rate (Subjects 5, 6, 7, and 9). Nonitalicized numbers refer to Key A; italicized numbers refer to Key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key.

ing on both keys was very low by the end of the study both in subjects whose responding did not come under verbal control and in subjects whose responding indicated transient verbal control (the exception being Subject 6). This result seems to indicate that persistent contact with the schedule of reinforcement, which, in the present case, requires only one response per 5.5 s to earn maximum points, gradually undermines verbal control. This is particularly well demonstrated by Subjects 5 and 8, who each made only one response per interval in their final session of participation, thus responding with maximum efficiency on

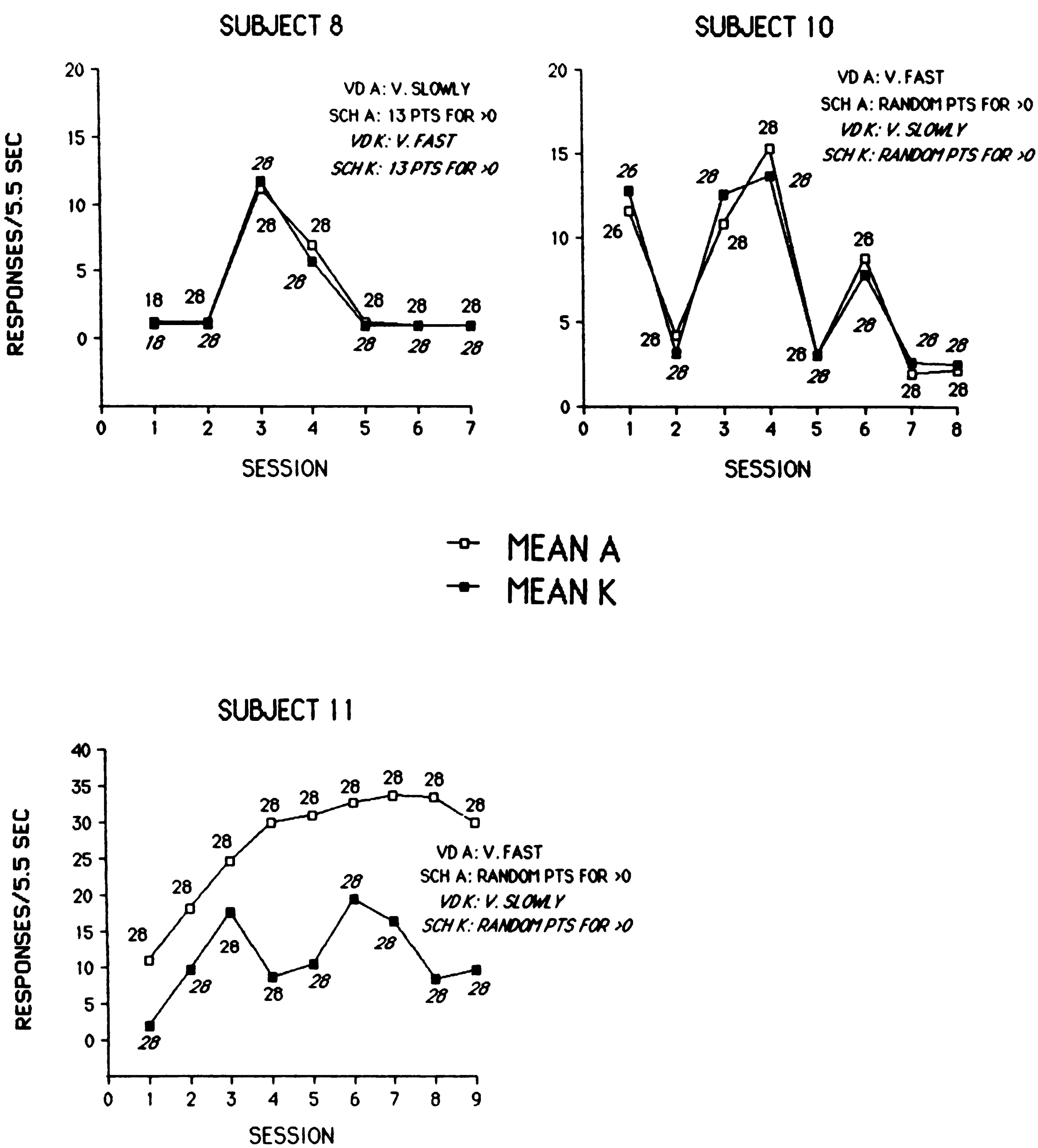

Fig. 6. Mean sessional response rates on Keys A and K (open and filled squares, respectively) and number of verbal description points earned in sessions for subjects for whom choice of verbal description did not differentially affect response rate (Subjects 8 and 10) and for whom choice of verbal description maintained differential response rates (Subject 11). Nonitalicized numbers refer to Key A; italicized numbers refer to Key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and schedule range, respectively, for each key.

the active schedule. In the present case, "contact" with the schedule may only mean varying the response rate during a given session sufficiently to determine that lower and lower rates still earn the same number of points. A subject who consistently responded at a rapid rate on the key described as "press very fast" and who consistently responded at a very slow rate on the key described as "press very slowly" would not be able to make such a determination. Individual session data show considerable "experimentation" by all subjects in

Experiment 2, even during the period when verbal control was apparently manifested according to sessional means. Consequently, sessional averages tend to suggest differential verbal control more than do response rates in individual intervals. For example, Subject 5's mean response rates for Session 2 are 7.6 responses per interval for Key A and 19.2 responses per interval for Key K, indicating the expected verbal control. These data belie the fact that individual interval rates for Key A had a standard deviation of 6.34 with a sessional range of 0 to 30. Key K individual interval rates had a standard deviation of 9.86 with a sessional range of 0 to 33. Given that the number of points earned did not vary with this great variability in response rate, "contact" with the nondifferential consequences of the schedule might be said to have occurred.

Subject 11 demonstrated clear differential verbal control across all sessions. According to the above analysis of response-rate variability and its possible function in eliminating verbal control, we might expect the response-rate variability of Subject 11 to be low. Contradicting this suggestion, however, Subject 11 showed considerable response-rate variability in Sessions 1, 2, and 3. In Session 3, for example, the Key A individual interval rates had a standard deviation of 4.54 with a sessional range of 11 to 31, and Key K rates had a standard deviation of 6.57 with a sessional range of 8 to 28. Beginning in Session 4, however, when verbal control began to promote very large rate differences between the keys, within-session variability became low. In Session 8, for example, the Key A individual interval rates had a standard deviation of 1.40 with a sessional range of 30 to 37, and Key K rates had a standard deviation of 0.85 with a sessional range of 7 to 10. These data seem to indicate that, unlike the other subjects in Experiment 2 for whom high response-rate variability was the active variable in producing a loss of verbal control, verbal control may have been the active variable in producing low response-rate variability for Subject 11.

GENERAL DISCUSSION

Comparing the present data with those of previous researchers (Catania et al., 1982; Hayes et al., 1986; Matthews et al., 1985), we see clear differences in the strength of verbal control. These differences likely reflect the relative discriminative control of the schedules used. The Catania et al. and Matthews et al. data indicate poor control by the schedule in the absence of verbal rules. The same can be said for the Hayes et al. data, although one schedule (either DRL or FR) was generally able to gain control over responding in the absence of a verbal rule. Experiment 1 of the present study, in contrast, demonstrated precise discriminative schedule control over response rate in the absence of verbal descriptions. This difference in schedule control may account for two discrepancies between the present and previous research: (a) the greater susceptibility of response rate to verbal manipulation seen in past research and (b) the decreased likelihood of response rate conforming to opposing schedules when those contingencies are contacted, as seen in this same research.

The greater discriminative control of the schedules used in the present research likely derives from the ease of attending to changes in the discrete number of points delivered as opposed to the more challenging task of estimating changes in the density of single point deliveries over time, as was the case in previous studies. As a consequence of the more precise discriminative control by the schedules in the present research, verbal control was evidenced only when the discriminative control of the schedules was decreased by use of nondifferential schedules (Experiment 2) and even then, control occurred only transiently (with the exception of Subject 11).

Although the discrepancy in results between previous research and the present study may derive from the discriminative control of the schedules employed, procedural differences in experimental instructions and in the establishment of verbal behavior may attenuate the validity of direct comparisons. In the present research, the experimental instructions explicitly identified response rate as the relevant behavioral dimension. Although this departure from previous research was used to restrict the range of behavior with which subjects would concern themselves, thus removing the occasional necessity of repeated experimental instructions, this expedient exploitation of our subjects' verbal capacities may have introduced a rule-governed element into behavior that other researchers have established in a more purely contingency-shaped fashion. It is well known that rule-governed responding has properties differing from those of contingency-governed responding (Skinner, 1969). The extent to which those differences affected the present research requires experimental analysis. Although we have generated data in our laboratory indicating that the schedules we employed in this research can achieve discriminative control over response rate with minimal instruction, the effects of superimposing verbal descriptions on such contingency-established baselines may, indeed, produce results different from those presented in this paper. The present study also departed from previous research in the method used to establish verbal stimuli specifying response rate. Hayes et al. (1986) employed direct instructions. Catania et al. (1982) and Matthews et al. (1985) shaped sentence completions. The present research differentially reinforced the selection of verbal descriptions either with or without the prior specification of that reinforcement contingency through an instruction. The degree of functional similarity between our procedure and those employed previously is of vital importance to direct comparisons.

Assuming the various methods of establishing verbal stimuli that specify response rate to be functionally similar, procedural differences between the past and present research may have differentially evoked social contingencies on rule following. In the present study and in the prior studies addressed, there was no programmed reinforcement contingency for correspondence between verbal description and nonverbal behavior (cf. the explicit reinforcement of correspondence programmed by Risley & Hart, 1968). The contingencies on correspondence, consequently, are related to stimulus properties of the agent producing the verbal descriptions specifying response rate. As discussed by Cerutti (1989), compliance with instructions (in the present case, correspondence between nonverbal behavior and shaped verbal behavior) may depend on the history of reinforcement associated with the agent delivering the instruction: The agent may accrue stimulus control properties occasioning compliance due to an experimental history of reinforcing compliance or by virtue of membership in classes of agencies that have previously reinforced compliance.

In the procedures of Catania et al. (1982) and Matthews et al. (1985), an experimenter was conspicuous by virtue of providing feedback for verbal responses. This arrangement, in which the experimenter "grades" the verbal responses of subjects and then is present (not only for the brief period during which feedback is provided but for the entire session), may bring a considerable social contingency into play due to the experimenter's membership in classes of agents ("experimenters," "experts," or perhaps more generally, "authority figures") that are discriminative of the reinforcement of compliance. The experimenter may even be construed to possess ongoing information regarding subject response rate and therefore to be aware immediately when subjects deviate from their response descriptions. The social contingencies in the Hayes et al. (1986) manipulation were different but perhaps no less compelling. The experimenter read response-rate instructions aloud to the subject, who followed on a printed sheet. Here again, although the experimenter was physically absent thereafter, he was conspicuous as the source of the instructions designating response rate and possibly functioned as a discriminative stimulus for compliance.

The present procedure differs from each previously discussed in that (a) the experimenter was physically absent during sessions and (b) the verbal stimuli regarding response rate were presented by the computer. Both of these procedural differences could potentially decrease the effect of social contingencies on rule-following behavior by decreasing the likelihood that the instructional agent (the computer) belongs to a class of agents discriminative of reinforcement contingencies on compliance. Thus, a verbal description shaped by a computer may be less effective in controlling response rate than one shaped or instructed by a human experimenter. Indeed, given the dearth of social and other consequences available to a computer or previously delivered to subjects by a computer for rule compliance or noncompliance (exempting from this argument, of course, those individuals who frequently interact with a computer), one might question the role of the computer in maintaining rule-behavior correspondence. It is conceivable, given the above analysis, that a human experimenter delivering instructions for response rate might have controlled response rate on our schedules to the extent seen in the studies by Catania et al. (1982), Matthews et al. (1985), and Hayes et al. (1986). Explanatory references to social contingencies are presently speculative, however, because social contingencies were not manipulated in the present research. Future research may profitably investigate both the differences between the various procedures for producing verbal descriptions discussed in the present paper and the extent to which the agents instrumental in producing those descriptions are discriminative of compliance.

The present study appears to represent one pole of a continuum of conditions in which discriminative control by the schedule is powerful and precise. Previous research demonstrating the prepotence of verbal rules over schedules appears to represent the other pole by virtue of the absence of such schedule control. This lack of precise schedule control is not surprising, of course, given the difficulties encountered in obtaining precise schedule control in humans. The present results do indicate, however, that this lack of schedule control in previous research may have been a special condition allowing verbal control to manifest itself.

REFERENCES

Ader, R., & Tatum, R. (1961). Free-operant avoidance conditioning in human subjects. *Journal of the Experimental Analysis of Behavior,* **4,** 275–276.

Burnstein, D. D., & Wolff, P. C. (1964). Shaping of three-man teams on a multiple DRL-DRH schedule using collective reinforcement. *Journal of the Experimental Analysis of Behavior,* **7,** 191–197.

Catania, A. C., Matthews, B. A., & Shimoff, E. (1982). Instructed versus shaped human verbal behavior: Interactions with nonverbal responding. *Journal of the Experimental Analysis of Behavior,* **38,** 233–248.

Cerutti, D. T. (1989). Discrimination theory of rule-governed behavior. *Journal of the Experimental Analysis of Behavior,* **51,** 259–276.

De Luca, R. V., & Holborn, S. W. (1985). Effects of a fixed-interval schedule of token reinforcement on exercise with obese and non-obese boys. *Psychological Record,* **35,** 525–533.

Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement.* New York: Appleton-Century-Crofts.

Harzem, P., Lowe, C. F., & Bagshaw, M. (1978). Verbal control in human operant behavior. *Psychological Record,* **28,** 405–423.

Hayes, S. C., Brownstein, A. J., Zettle, R. D., Rosenfarb, I., & Korn, Z. (1986). Rule-governed behavior and sensitivity to changing consequences of responding. *Journal of the Experimental Analysis of Behavior,* **45,** 237–256.

Leander, J. D., Lippman, L. G., & Meyer, M. E. (1968). Fixed interval performance as related to subjects' verbalizations of the reinforcement contingency. *Psychological Record,* **18,** 469–474.

Martin, G., & Pear, J. (1988). *Behavior modification: What it is and how to do it* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.

Matthews, B. A., Catania, A. C., & Shimoff, E. (1985). Effects of uninstructed verbal behavior on nonverbal responding: Contingency descriptions versus performance descriptions. *Journal of the Experimental Analysis of Behavior,* **43,** 155–164.

Matthews, B. A., Shimoff, E., Catania, A. C., & Sagvolden, T. (1977). Uninstructed human responding: Sensitivity to ratio and interval contingencies. *Journal of the Experimental Analysis of Behavior,* **27,** 453–467.

Risley, T. R., & Hart, B. (1968). Developing correspondence between the non-verbal and verbal behavior of preschool children. *Journal of Applied Behavior Analysis,* **1,** 267–281.

Shimoff, E., Catania, A. C., & Matthews, B. A. (1981). Uninstructed human responding: Sensitivity of low-rate performance to schedule contingencies. *Journal of the Experimental Analysis of Behavior,* **36,** 207–220.

Skinner, B. F. (1969). *Contingencies of reinforcement: A theoretical analysis.* New York: Appleton-Century-Crofts.

Weiner, H. (1969). Controlling human fixed-interval performance. *Journal of the Experimental Analysis of Behavior,* **12,** 349–373.

Weiner, H. (1970). Human behavioral persistence. *Psychological Record,* **20,** 445–456.

Received May 11, 1989
Final acceptance March 15, 1990