The Effects of Verbal Performance Descriptions on Nonverbal Operant Responding

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© Laine Torgrud

A thesis submitted to the Faculty of Graduate Studies in partial fulfillment of the requirements for the Degree of Master of Arts

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Abstract

The effect of reinforced verbal descriptions on key-pressing rate was studied in the context of reinforcement for pressing on both nondifferential schedules and schedules opposed to the verbal description. Undergraduates' key presses produced points exchangeable for lottery tickets on alternating schedules. Subjects experienced one of three 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" on that particular 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. The nondifferential schedule for both keys either delivered the same point value or a randomly chosen value regardless of pressing rate. Correspondence of pressing rate to verbal description was transient or absent. In Experiment 3 subjects experienced initial correspondence between verbal description and schedule followed

by either (a) the abrupt introduction of an opposing schedule or (b) the introduction of a nondifferential schedule followed by introduction of the opposing schedule. The results showed that pressing rate sometimes conformed to the opposing schedule and sometimes maintained correspondence with the verbal description. Whether verbal control was lost or maintained appeared a function of the extent of contact with the opposing contingency. In addition, verbal control under the nondifferential contingency was enhanced over that seen in Experiment 2. The precise discriminative control of the schedules employed may account for differences in the level of verbal response-rate control between the present and past research.

The Effects of Verbal Performance Descriptions on Nonverbal Operant Responding

Verbal and nonverbal behavior constitute two broad operant classes which 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). Recently, a number of human operant studies have begun to directly investigate the relationships between verbal and nonverbal behavior.

According to Catania, Matthews, and Shimoff (1982), verbal behavior enters into research on nonverbal human operant behavior in several ways. First, an experimenter may obtain verbal reports following an experimental manipulation. Such verbal behavior may be dependent on prior nonverbal responding, or it may reflect earlier overt or covert verbal behavior upon which nonverbal responding depended (e.g., Harzem, Lowe, & Bagshaw, 1978). Second, an experimenter may give subjects instructions regarding their nonverbal behavior rather than establishing the behavior through experimental contingencies. It is well known that instructed or rule-governed responding may have different properties from its contingency-established counterpart. Rule-governed responding may be less sensitive to changes in associated contingencies than is contingency-shaped behavior (Shimoff, Catania, & Matthews, 1981), that is, the influence of instructions may outweigh the influence

of the scheduled experimental consequences. We can conclude, therefore, that rule-governed responding can be manipulated such that it is not in complete accord with the programmed experimental contingencies, although, as noted by Kaufman, Baron, and Kopp (1966), as cited by Harzem et al. (1978), this effect will be weakened if the rule and experimental contingency are widely discrepant.

Rule-governed responding is usually promoted by ensuring that verbal behavior describing the response in question comes into the repertoire of the subject. Verbal behavior describing the response requirement can be engendered in two ways: by direct instruction (rule-governed), or by reinforcing approximations to such a verbalization (contingency-governed). Catania, Matthews, and Shimoff (1982) investigated the differential effects on the nonverbal performance itself of these two methods for establishing a verbal description of nonverbal performance. In their procedure college students' button presses produced points that were exchangeable for money on alternating variable-ratio (VR) and variable-interval (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 behavioral descriptions. This verbal control occurred even when the description was in opposition to the scheduled contingency (e.g., the subject would

press 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, Catania, and Shimoff (1985) extended the shaping aspect of the above paradigm to investigate the effects on nonverbal responding of contingency descriptions (e.g., "In order to receive a point I must press until a random number has been reached"), as opposed to the performance descriptions used in the previous study (e.g., "In order to receive a point I must press rapidly"). Consistent with the earlier finding of Catania et al. (1982), the shaped verbal behavior was a more important determinant of response rate than were schedule differences, although this result was not applicable to all subjects. The fact that the behavior of three of the seven subjects did not correspond to the verbal contingency descriptions was assumed to reflect deficits in the verbal repertoires of these individuals relating to reinforcement schedules. These deficits would, for example, involve a subject saying "the machine works after a random number of presses" without going on to say "the more often you press, the more points you will get".

More recently, Hayes, Brownstein, Zettle, Rosenfarb, and Korn (1986) demonstrated the effectiveness of experimenter-delivered

instructions in controlling response rates on a multiple FR/DRL schedule. Instructions describing the best way to earn points on these schedules controlled pressing rate, even when the description was applied inaccurately to the schedules (i.e., when the DRL schedule was instructed as "rapid pushes" and the FR as "several seconds between pushes"). Hayes, Brownstein, Zettle, et al. (1986) further demonstrated that removal of the instructions resulted in contingency-sensitive performance that quickly conformed to the schedules in operation.

The general conclusion of the Catania et al. (1982) Matthews et al. (1985), and Hayes, Brownstein, Zettle et al. (1986) papers is that both shaped and instructed verbal behavior can exert even more powerful control over a motor response such as button pressing than do the actual contingencies on that response. This effect holds both when the verbal responses are performance descriptions and when the verbal responses are contingency descriptions, provided, in the latter case, that the subject has mastered a vocabulary of reinforcement schedules. In short, if the verbal description and the scheduled contingencies are put in opposition, the subject's behavior will conform to the verbal description rather than to the schedule.

Implicit in the above argument is the assumption that the scheduled contingencies would have differential control over the motor response in the absence of the verbal description. In the previous studies, differential control would be expected to occur through a subject's sensitivity to the increase in reinforcement associated with an increase

in response rate on the fast rate schedule (i.e., VR or FR). This sensitivity would result in more rapid responding on the VR or FR schedule than on the VI or DRL schedule. Differential control by the contingencies alone must be demonstrated in order to meaningfully discuss the effects of placing verbal descriptions in opposition to the scheduled contingencies. Close scrutiny of the Matthews et al. (1985) and Catania et al. (1982) data reveals, however, that the contingencies employed in these studies did not differentially control behavior in the absence of accompanying verbal descriptions. During periods when a verbal description had not yet been successfully shaped, the response rates were nearly identical on the two schedules. It would appear then, that in the absence of a verbal description of nonverbal behavior, the VR schedule did not promote a higher rate of responding than the VI schedule, with the consequence that these authors cannot claim successful opposition of a verbal description to any functionally different experimental contingencies.

Similarly, in Experiment 1 of Hayes, Brownstein, Zettle, 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, not on both. Response rates on the two schedules reflected this contact, being similar and high for two subjects (contacting only the FR schedule), similar and low for one subject (contacting only the DRL schedule), and dissimilar for one

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 employed to alter response rate, it is uncertain how powerful the schedule control would be in the absence of the instructions (indeed, the evidence suggests little differential control of response rate by the contingencies alone). Only after response-rate instructions brought about contact with both schedules (Experiment 2) was differential schedule control of response rate demonstrated.

Difficulties in demonstrating precise schedule control of human operant responding are not restricted to these studies or to these schedules. Several studies suggest intraspecies variability: Some humans have been demonstrated to respond at rapid constant rates on Fixed Interval (FI) schedules without a post-reinforcement pause (e.g., Leander, Lippman, & Meyer, 1968), while other humans, like most animals, emit lower response rates with post-reinforcement pausing that varies systematically with FI values (e.g., Weiner, 1969). Further, human responding has been shown insensitive to such schedule differences as FI vs. FR (Weiner, 1970) and to other changing schedules of reinforcement in a variety of procedures (Ader & Tatum, 1961; Harzem, Lowe, & Bagshaw, 1978; Matthews, Shimoff, Catania, & Sagvolden, 1977; Shimoff, Catania, & Matthews, 1981). As in the cases previously discussed, where verbal stimuli are explicitly opposed to the active schedule, verbal stimuli are often proposed as the

insensitivity-producing variable in this research. For example, Matthews et al. (1977) demonstrated insensitivity to VI vs. VR schedules when minimal instructions regarding the experimental task were employed. Shimoff et al. (1981) consider such task instructions to be instrumental in producing schedule insensitivity. My view, however, is that in Matthews et al. (1977) and in several of the previously discussed manipulations (Catania et al., 1982; Hayes, Brownstein, Zettle, et al. 1986; Matthews et al., 1985), poor discriminative schedule control is the more parsimonious explanation for the demonstrated verbal control of response rate.

The present study sought to further test the assertion that verbal descriptions can override schedule control. In the present case, however, this test involved the use of specially designed schedules whose discriminative control of response rate was clearly demonstrated in the absence of verbal rules. The present procedures were similar to those employed by Matthews et al. (1985) save for alterations designed to increase the power of the experimental demonstration.

First, and most importantly, the present study sought to increase the discriminative control of the schedule contingencies over that of past research and to demonstrate this control prior to the institution of verbal control. Assuming the verbal control demonstrated in past research to reflect poor discriminative control on the part of the schedules, the present, highly discriminative schedules were expected to generate a corresponding decrease in verbal control. The programmed

contingencies on the subjects' motor behavior awarded points maximally for response rates lying within a specified range, while providing progressively fewer points for response rates increasingly dissimilar from that range. Thus, for example, two schedules could be created, one which delivers points maximally for a range of high response rates and delivers progressively fewer points for lower response rates, and another which delivers points maximally for slow response rates while delivering progressively fewer points for higher response rates. Points were provided at a constant interval (every 5.5 s) for the response rate during the interval preceeding each point delivery. These schedules had the advantage over the schedules employed by Matthews et al. (1985) and Hayes, Brownstein, Zettle et al. (1986) of being easily adjusted in terms of similarity, both to each other and to the verbal descriptions they would oppose. These adjustments were possible through changes in the value of the maximally point-awarded (MaxPA) response-rate range for each schedule. Baseline measures were taken to demonstrate behavioral 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 empirically demonstrated.

Second, performance descriptions rather than contingency descriptions were used, since 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 allowed for precise quantification of the disparity between the chosen verbal description and the MaxPA response-rate range as well as providing a variety of verbal descriptions, more or less opposing to 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.

Two distinct experimental procedures were applied in Experiment 1, each to two subjects. As in the Matthews et al. (1985) experiments, responses were made on each of two response keys (the "a" and "k" keys of a computer keypad) in alternating cycles. In phases requiring the reinforcement of a verbal performance description, each subject completed a sentence stem describing "the best way to earn points on key X" following the opportunity to earn points through presses on that key. A baseline of medium rate schedule-controlled responding was demonstrated for all four subjects in the initial phase of both procedures, followed, for the two subjects in the second procedure, by a demonstration of schedule-controlled high- and low-rate responding. Subsequently, the first procedure awarded maximum points for a verbal description of "press very fast" for one key, and "press very slowly" for the other, while gradually changing the schedule contingencies to oppose

these verbal descriptions. The second procedure instituted maximum point awards for verbal descriptions corresponding to the high- or low-rate schedules, then changed the MaxPA verbal description to oppose the schedule contingencies. It was expected that both procedures would demonstrate less verbal control of response rate than previous research because of increased discriminative schedule control.

Subsequent to Experiment 1, two additional experiments examined verbal control under conditions designed to alter the strengths of discriminative verbal and schedule control. The General Method section which follows refers to elements common to all three experiments. Specific procedures for each individual experiment are discussed subsequently.

General Method

Subjects

Eleven female and four 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 parallel those of Matthews et al. (1985).

Apparatus

The study was conducted in a 4 m X 4 m research room in the Psychology building at the University of Manitoba. The room contained a desk for the experimental apparatus and a chair. Subjects seated in the chair faced the experimental apparatus, which consisted of a Macintosh Plus microcomputer (screen size: 19 cm x 15 cm) and a modified

Macintosh keypad. Two of the keypad keys (the "a" and the "k") were clearly labelled as the response keys using masking-tape squares which displayed the corresponding letter in large 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 responses on each schedule, to record subjects' verbal descriptions, and to dispense points that were later exchangeable for tickets in an experimenter-run lottery. Directly 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

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 left 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 labelled "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 labelled with an "a." When a "k" appears on the screen you can earn points by pressing the key on the

keyboard that is labelled with a "k." The computer will add points to your point total at regular intervals.

The following paragraph was included only 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, nearest to 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 nearest 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 7 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 consequated intervals per key presentation.

Based on the response rates obtained by other researchers and pilot work conducted by this researcher, a 5-level response distribution was calculated such that specific response-rate ranges could be reinforced. For example, based on work by Catania et al. (1982) and Matthews et al. (1985) a response range of 11-15 responses per 5.5 s interval appeared to be a "medium" rate of key pressing for the typical undergraduate student. Based on their maximum observed rates from these articles of about 35 responses per 5.5 s and considering that responding can reach a minimum of 1 response per 5.5 s and still be considered "responding", the following categories were established: "very fast"- >21 responses per interval; "fast"- 16-20 responses per interval; "medium"- 11-15 responses per interval; "slowly"- 6-10 responses per interval; "very slowly"- 1-5 responses per interval.

Token points were established for each of the response-rate ranges such that certain rates were awarded maximum points. These points, which were exchangeable for lottery tickets at the end of each session, were added to one of two counters located 2.5 cm from the top of the screen every 5.5 s. One counter, positioned 4 cm from the left side of the screen, was labeled "Points for 'a':," and kept track of 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 kept track of all points earned on key "k." For example, for a medium response rate used in the

first phase of Experiment 1 the point breakdown for the five categories was 2, 3, 5, 3, 2 listed from "very fast" to "very slowly" 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 5, 4, 3, 2, 1; the distribution of point values designed to generate fast responding was 4, 5, 3, 2, 1; the distribution of point values designed to generate slow responding was 1, 2, 3, 5, 4; and the distribution of point values designed to generate very slow responding was 1, 2, 3, 4, 5. The point values were chosen such that, regardless of the MaxPA response-rate range, points would decrease as the response rate fell further outside that range, and such that the total points available would remain constant. In phases requiring nondifferential reinforcement of responding the point values were made equal across intervals (e.g., 13, 13, 13, 13, 13).

The exceptional cases were the random subjects for whom these procedures were not employed. Instead, the computer awarded particular 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, depending on the subject's rate of responding during that interval. Presses on the key not corresponding to the symbol on the screen had no programmed consequences. A complete

absence of responding during an interval added "0" points to 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, activation of a key. This produced 7 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 fast", "press fast", "press at a medium rate", "press slowly", and "press very slowly", numbered from 1 to 5, respectively. The instruction "Press the number corresponding to your selection." preceeded the stems. Following the selection of a number either from the numerical row at the top of the keypad or from the calculator-style block at the side 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 from "press very fast" to "press very slowly," respectively. Thus, a 12, 24, 36, 48, 60 verbal description distribution

maximally reinforces a description of "press very slowly." Points for verbal descriptions were usually chosen to equalize the number of points potentially available for actual key pressing and for verbal descriptions of key pressing (exceptions are discussed under the specific procedures). This involved multiplying the schedule points available by 12 to calculate verbal description points, since verbal description points were earned once per key presentation, while schedule points were earned 12 times per key presentation.

At the end of a session the experimenter administered a brief, pen and paper, post-session questionnaire designed to assess subjects' verbalizations of their within-session point earning strategies (see Appendix A). In addition, at the end of the study the experimenter administered a pen and paper, post-study questionnaire (see Appendix B).

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 (PWR, for Percentage Within 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.

Experiment 1

Method

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

Design. In Experiment 1 two subjects (Subjects 1 and 2) were required to respond on a schedule (the same for both keys) that awarded maximum points for a medium response rate (see Procedure for a description of the programmed contingencies). Following the maintenance of a stable rate of responding on both keys, a verbal description contingency was introduced where subjects received maximum points for responding "press very fast" in response to the sentence stem referring to the key marked by a "k", and received maximum points for responding "press very slowly" in completing the sentence referring to the key marked by an "a". When a stable rate of responding for both key-pressing and verbal description was achieved in this second condition, the density of reinforcement associated with different response rates was altered gradually such that very fast rates of responding received the most points on key "a" (associated with the verbal description "press very slowly") and very slow rates of responding received the most points on key "k" (associated with the verbal description "press very fast").

Two other subjects (Subjects 3 and 4) were required to respond on a schedule which awarded maximum points for a medium response rate. Once a stable rate of responding was achieved on both keys the

contingencies were suddenly changed such that the "a" key provided maximum points for very slow rates of responding while the "k" key provided maximum points for very fast rates of responding. When a stable rate of responding was achieved on these schedules verbal performance descriptions opposing the actual schedules in operation were introduced gradually. The two different procedures were employed to examine differential effects of gradually introducing opposing verbal descriptions or gradually introducing opposing contingencies.

Procedure.

The first experiment contained two distinct procedures, each involving multiple phases. 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 PWR stability criterion was reached, point awards for sentence stem completion were interposed between key pressing segments. The point distribution for "a" descriptors was 12, 24, 36, 48, 60. The point distribution for "k" descriptors was 60, 48, 36, 24, 12. Thus, for key "a," descriptors of "press very slowly" received maximum points while for key "k," descriptors of "press very fast" received maximum points. The prior schedule of reinforcement was maintained to maximally reinforce a medium rate on both keys. When stability criteria for both PWR and for verbal descriptions were reached, the contingencies on response rate were changed gradually to oppose the MaxPA verbal description. Both

stability criteria were required for both keys prior to each schedule change. Contingencies on key "a" were changed first to 4, 5, 3, 2, 1, maximally reinforcing a fast rate, and then to 5, 4, 3, 2, 1, maximally reinforcing a very fast rate. Contingencies on key "k" were changed first to 1, 2, 3, 5, 4, maximally reinforcing a slow rate, and then to 1, 2, 3, 4, 5, maximally reinforcing a very slow rate. The points for verbal descriptions remained unchanged throughout these phases.

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 the PWR criterion for both keys, the response-rate contingencies were changed to 1, 2, 3, 4, 5 for key "a", maximally awarding points for a very slow rate, and to 5, 4, 3, 2, 1 for key "k", maximally awarding points for a very fast rate. Following the achievement of the PWR criterion for both keys, verbal description point distributions of 12, 24, 36, 48, 60; 12, 24, 36, 60, 48; 24, 36, 60, 36, 24; 48, 60, 36, 24, 12; and 60, 48, 36, 24, 12 were applied successively to key "a," while verbal description point distributions of 60, 48, 36, 24, 12; 48, 60, 36, 24, 12; 24, 36, 60, 36, 24; 12, 24, 36, 60, 48; 12, 24, 36, 48, 60 were applied successively to key "k". The response-rate contingencies remained unchanged for the two keys. Thus, the MaxPA verbal description for keys "a" and "k" was gradually moved from a descriptor corresponding with, to one opposed to, the MaxPA pressing rate. The achievement of stability criteria for PWR and verbal description 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.

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 (PWR, for Percentage Within Range), and (c) the number of points earned for verbal descriptions on keys "a" and "k." The number of points for verbal descriptions were calculated by summing the 7 responses per session describing each key using the following formula: The point values 12, 24, 36, 48, 60 for verbal descriptions correspond to 0, 1, 2, 3, 4 points, respectively. Consequently, the number of points earned for sentence completions describing a given key during any session ranges from 0, for descriptions opposing the MaxPA description, to 28, for descriptions consistently matching the MaxPA description. In each Figure, mean sessional response rate is indicated by open (key "a") and filled (key "k") points. PWR values are indicated by numbers without parentheses; verbal description points are indicated by numbers within parentheses. All numbers referring to key "a" are in plain type; all numbers referring to key "k" are italicized.

Figure 1 shows the mean sessional response rate, PWR values, and the total verbal description points for keys "a" and "k" across sessions for Subject 1. In terms of key pressing contingencies, the first 4 sessions of Figure 1 show sessional means falling within the MaxPA

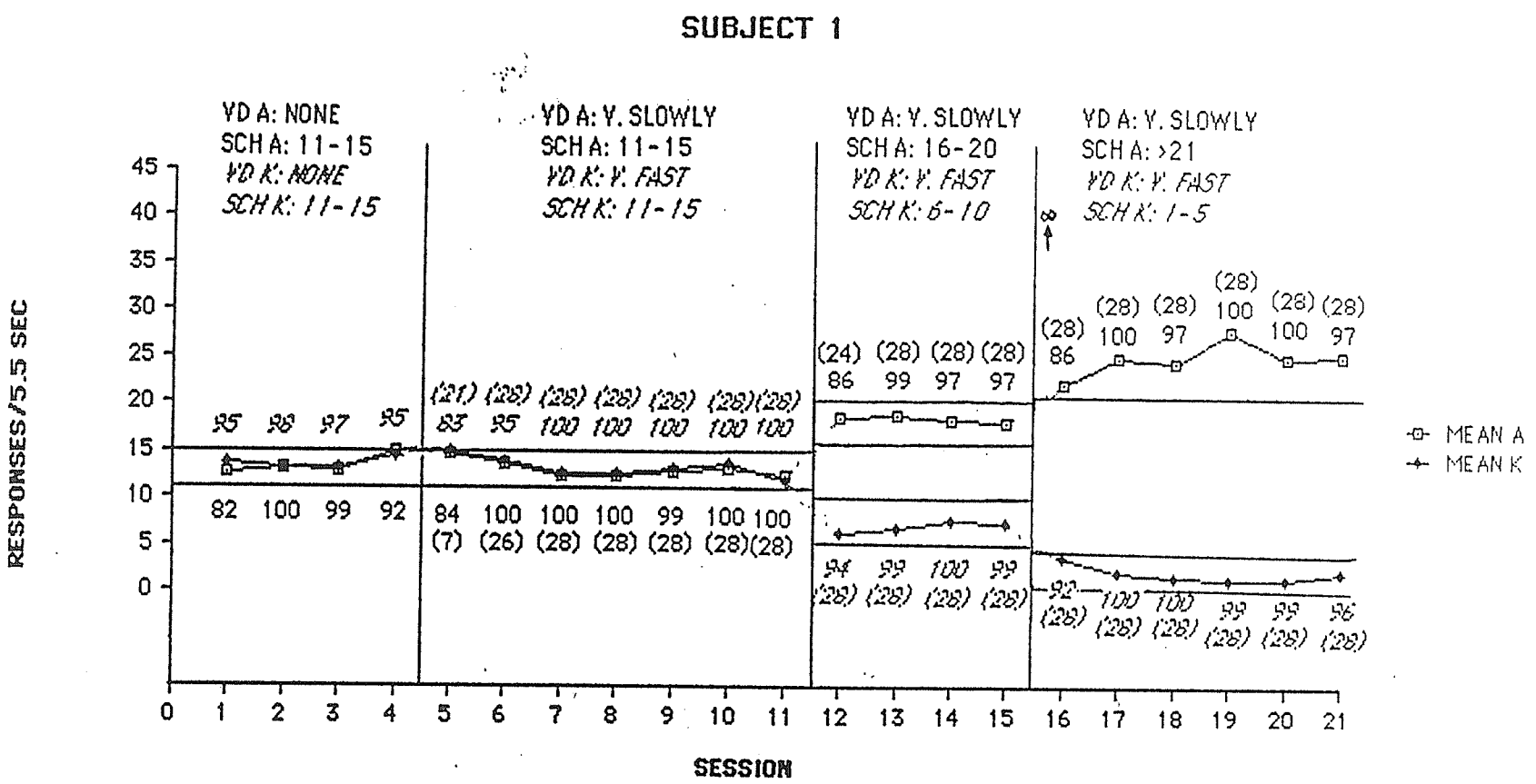

Figure 1. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 1. Numbers in plain type 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 (A and K).

response-rate range (11 to 15 responses/interval) and criterion PWR values after Session 1. All mean sessional response rates remained within the MaxPA ranges, despite shifts in those ranges in Sessions 12 (16-20 for key "a"; 6-10 for key "k") and 16 (>21 for key "a"; 1-5 for key "k"). PWR values were consistently above criterion, with the exception of Sessions 1, 5, 12, and 16, the first sessions of new phases. Discriminative and differential schedule control of response rate was clearly demonstrated. In terms of verbal descriptions, Sessions 5 through 21 show the MaxPA verbal description of "press very slowly" for key "a," and "press very fast" for key "k" to be consistently chosen by Session 7, and to remain so for the duration of the experiment, save for Session 12 for key "a." Choice of verbal description had no effect on key pressing rate. Despite lack of correspondence between verbal description and schedule contingency beginning in Session 5, pressing rates conformed to the active schedule in all sessions.

Figure 2 shows the sessional dependent measures data for Subject 2. The first 4 sessions of Figure 2 show sessional means falling within the MaxPA response-rate range (11 to 15 responses/interval) and criterion PWR values after Session 1. All mean sessional response rates remained within the MaxPA ranges. PWR values took several sessions to reach criterion after the first pressing rate contingency shift (Sessions 11-16), but quickly reached criterion following the second shift (Sessions 17-21). As with Subject 1, clear schedule control of response rate was demonstrated. In terms of verbal descriptions, Sessions 5

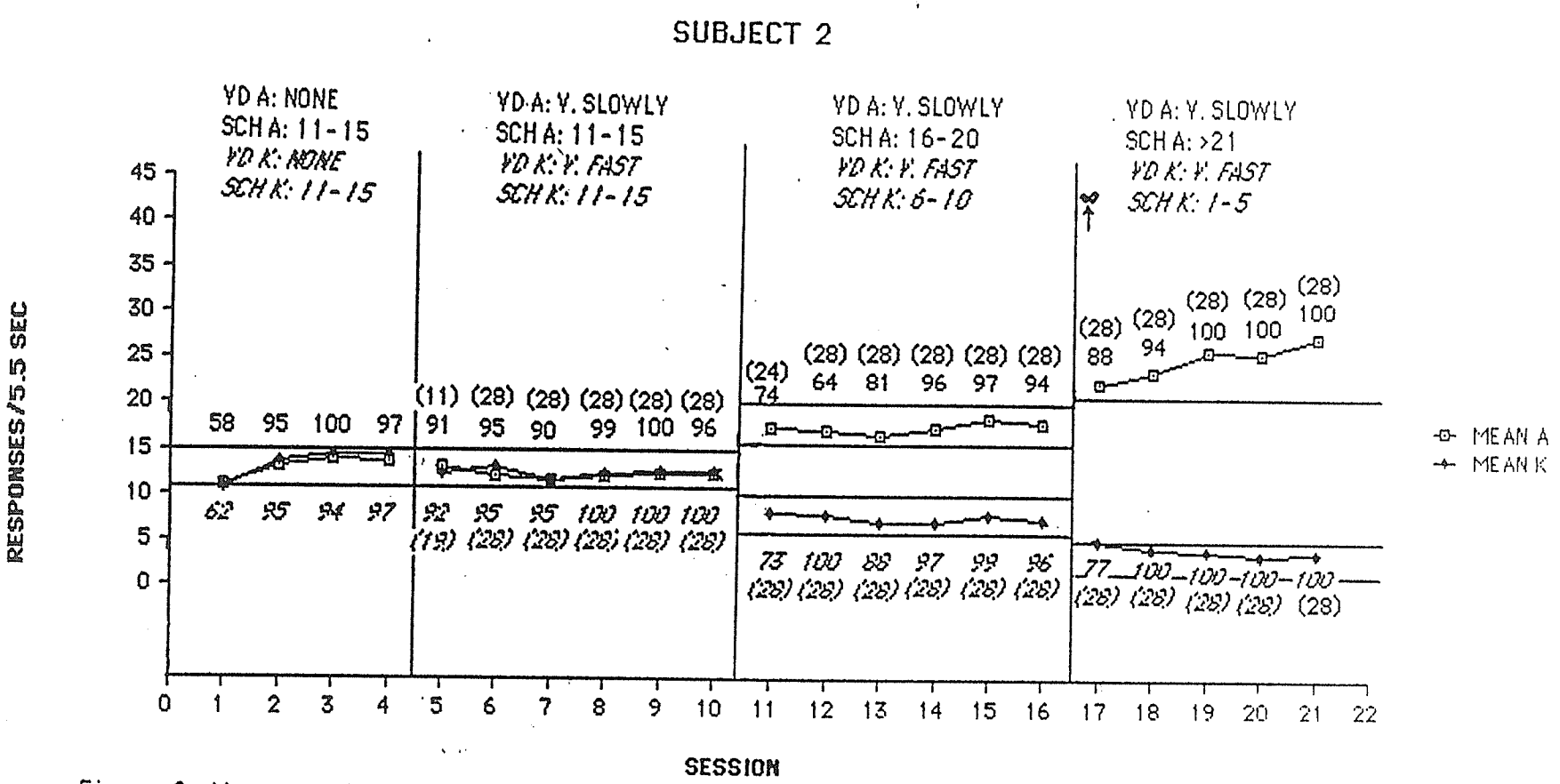

Figure 2. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 2. Numbers in plain type 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 (A and K).

through 21 show the MaxPA verbal description of "press very slowly" for key "a," and "press very fast" for key "k" to be consistently chosen by Session 6, and remain so for the duration of the experiment, save for Session 11 for key "a." As demonstrated by Subject 1, the data for Subject 2 show verbal description to have no effect on key pressing rate. Pressing rates conformed to the active shedule regardless of the verbal description chosen.

Figure 3 shows the sessional dependent measures data for Subject 3. The first 4 sessions of Figure 3 show sessional means falling within the MaxPA response-rate range (11 to 15 responses/interval) and criterion PWR values after Session 1. Sessions 5 through 28 show sessional means falling within the MaxPA response-rate range of 1-5 for key "a," and >21 for key "k," except for the key "a" value in Session 5 which slightly exceeded that range. PWR values were consistently above criterion, with the exception of Session 5. As in Subjects 1 and 2, clear schedule control of response rate was demonstrated. Sentence completion tasks were introduced in Session 11. The MaxPA verbal description for key "a" was changed gradually from "press very slowly" through to "press very fast," while the MaxPA verbal description for key "k" was changed gradually from "press very fast" to "press very slowly," with phase shifts in Sessions 14, 17, 21, and 25. The MaxPA verbal response was consistently chosen, except in the first session following a shift, and in Session 22 for key "k." Verbal description had no effect on key pressing rate, despite chosen descriptions which increasingly opposed the active schedule.

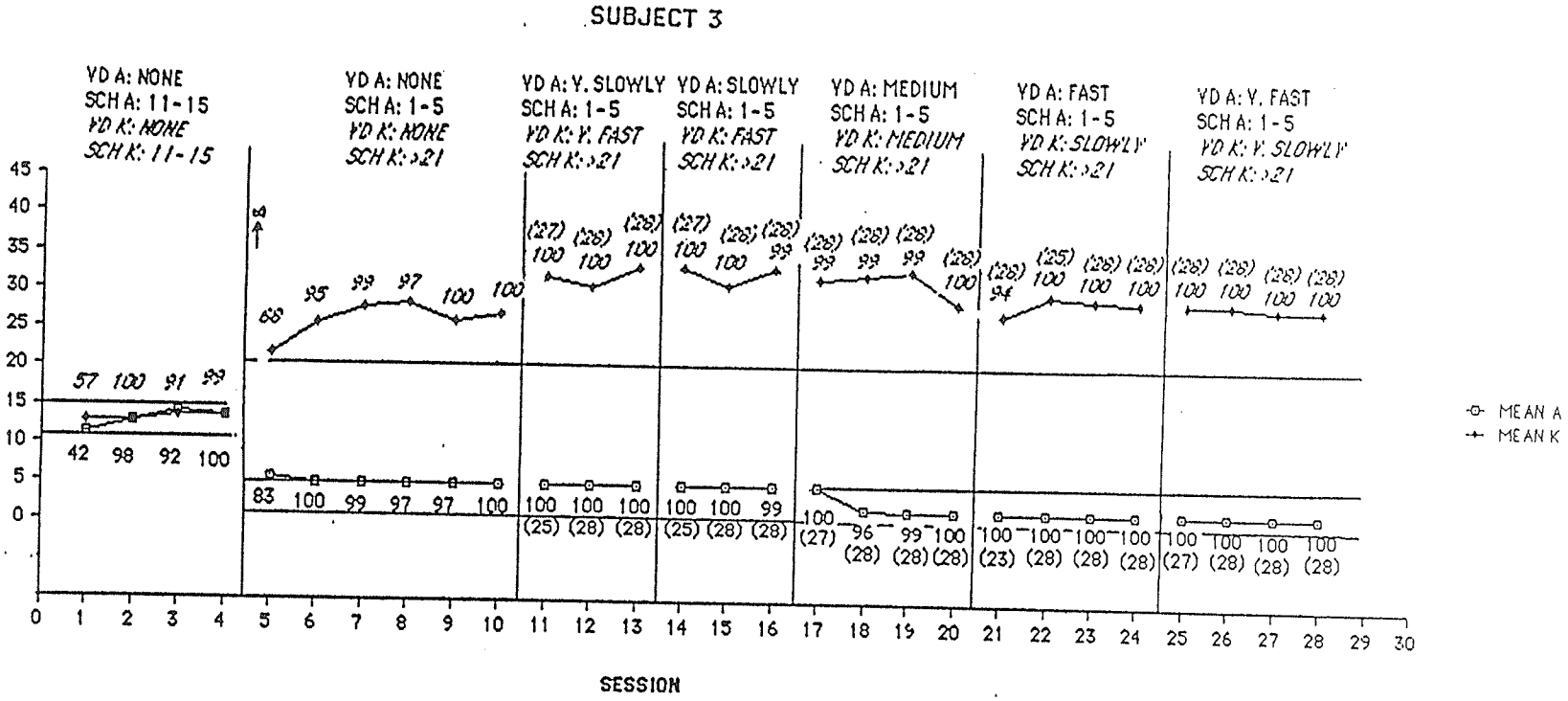

Figure 3. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 3. Numbers in plain type 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 (A and K).

Figure 4 shows the sessional dependent measures data for Subject 4. The first 2 sessions of Figure 4 show sessional means falling outside the MaxPA response-rate range (11 to 15 responses/interval) with correspondingly low PWR values. Not until Session 6 are both sessional means within the MaxPA ranges and PWR values at criterion. Sessions 9-36 show sessional means for key "k" falling quickly within the MaxPA response-rate range of >21 responses/interval and the rapid establishment of criterion PWR's. Key "a" sessional means remain above the optimal range of 1-5 responses/interval until Session 15 when PWR values reach criterion. As in Subjects 1-3, clear schedule control of response rate was demonstrated. Verbal desciptions were introduced in Session 18. The MaxPA verbal description for key "a" was moved from "press very slowly" through to "press very fast," while the MaxPA verbal description for key "k" was moved from "press very fast" to "press very slowly," with phase shifts in Sessions 21, 25, 29, and 33. The MaxPA verbal response was consistently chosen, except in the first session following a shift, and in Session 24 for key "k." As shown by Subject 3, the data for Subject 4 show verbal description to have no effect on pressing rate, despite MaxPA descriptions which increasingly opposed the active schedule.

Discussion

The mean sessional response rate and PWR data of Experiment 1 clearly show that the schedules used in the present study exert

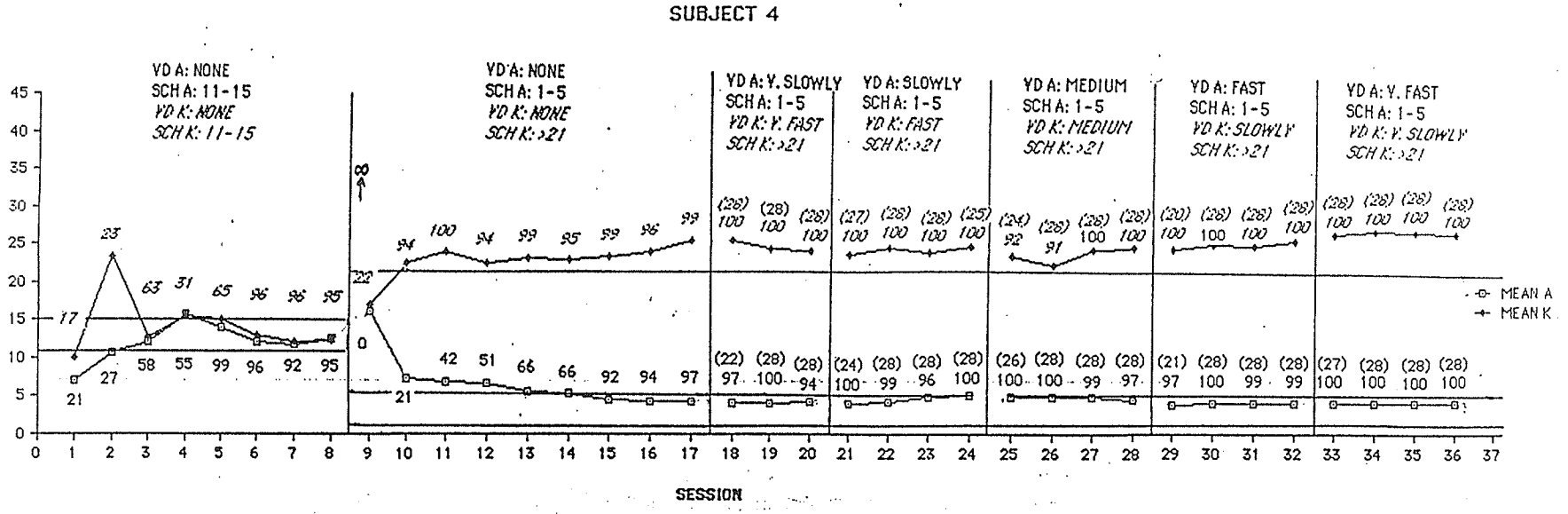

Figure 4. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 4. Numbers in plain type 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 (A and K).

discriminative control over response rate. Unlike in past research (Hayes, Brownstein, Zettle, et al., 1986; Matthews et al., 1985), the present study makes this demonstration of schedule control before adding 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.

Experiment 1 clearly indicates that the contingencies on verbal descriptions (henceforth refered to as "verbal control") and on key pressing (henceforth refered to as "schedule control") 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 effects were observed regardless of whether extreme verbal descriptions were established first, with schedule requirements gradually changing in opposition, or whether the schedule requirements were first made extreme, with verbal descriptions gradually changing in opposition. These results contrast with those of Catania et al. (1982), Matthews et al. (1985), and Hayes, Brownstein, Zettle et al. (1986) in which pressing rate was demonstrated to correspond to the verbal description or instruction, regardless of the programmed schedule for key-pressing behavior. As expected, evidence for verbal control over pressing rate in

the present research was nonexistent, presumably due to the powerful discriminative control of the schedules employed. There are two major reasons for the apparent strength of discriminative control of response rate by the schedule in the present research.

First, because of the design of the schedule, with points for schedule performance during an interval coming in evaluatable units, subjects can easily identify performances that do not correspond to schedule contingencies. Since it is easily discriminable to subjects when their performance has fallen outside the MaxPA range this type of reinforcement schedule would tend 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 would serve to increase discriminative control of response rate by the schedule. The past researchers mentioned above did not undertake to establish schedule control prior to instituting verbal control, both contingencies being implemented simultaneously.

As noted by Kaufman et al. (1966), as cited by Harzem et al. (1978), rules will exert less control when the rule and schedule are widely discrepant. As a consequence of the precise discriminative schedule control established at widely differing response-rate ranges, and the verbal descriptors employed in the present study, the verbal description

and schedule pointed behavior in widely discrepant directions. The present study may have invoked a larger discrepancy between verbal description and schedule than was seen in past research. Again, this effect is attributable to the precise discriminative control of the schedule.

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, Brownstein, Zettle, et al., 1986; Matthews et al., 1985) demonstrating verbal control of response rate. The relative verbal and schedule control manifested presumably depends on the discriminative control of verbal description and schedule, with the latter control increased in the present research through prior contingency exposure and the nature of the schedule.

Experiment 2 was designed to decrease the level of discriminative control by the schedule to allow discriminative control by the verbal description to appear. 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 changes in points earned corresponding to changes in response rate, thus decreasing the chances that schedule contact would prevent discriminative control by the verbal description.

Two distinct methods were investigated. The first method used a schedule of reinforcement which 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.

The second method was designed to anticipate two possible weaknesses of the first method, with respect to establishing verbal control over key pressing rate. First, the second method used a schedule of reinforcement which awarded a randomly determined point value regardless of pressing rate (provided, again, that >0 responses 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 would increase the chances that the desired verbal description would be established after only a minimum of schedule exposure.

I hesitated to employ instructions because of Catania et al.'s (1982) demonstration that instructions may be more variable in their effects than shaped verbal responses, however, the present instructions were more similar to shaping in two ways. First, the present "instructions" specified the consequences for verbal responses rather than

directly specifying the relationship between response rate and schedule points. Second, points were awarded for verbal descriptions. The "instructions" employed in the present study might best be conceptualized simply as instructions about contacting verbal contingencies which ensured rapid verbal contingency contact, rather than as an instance of direct instruction of response rate. Furthermore, Hayes, Brownstein, Zettle, et al. (1986), Experiment 2, demonstrated consistent control of response rate by instructions.

Experiment 2

Method

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

Design. All subjects experienced one of two types of nondifferential schedule contingencies on both keys (wherein no particular response rate was MaxPA). Four subjects received the same number of points (13) following each interval regardless of response rate; three subjects received a random number of points (ranging from 11 to 19) following each interval regardless of response rate. The increase in point values over those delivered in the Experiment 1 was designed to decrease the discriminative control of the schedule by virtue of the greater difficulty in determining the number of points added to the cumulative counter after each interval. Concomitantly, for both groups of subjects, sentence stem completions specifying "press very fast" received maximum points for one key, while stem completions specifying "press very slow" received maximum points for the other key.

Procedure.

The second experiment contained two similar procedures, each involving one phase. 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 verbal description point distributions were 12, 24, 36, 48, 60 for key "a," and 60, 48, 36, 24, 12 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 <3 responses/5.5 s) or until subjects had fulfilled their obligation for experimental credit.

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 pts- .05, 12 pts- .10, 13 pts- .10, 14 pts- .15, 15 pts- .20, 16 pts- .15, 17 pts- .10, 18 pts- .10, 19 pts .05. Consequently, the number of points awarded was independent of the number of responses emitted (for responses >0). Verbal description point distributions were 180, 144, 108, 72, 36 for key "a" and 36, 72, 108, 144, 180 for key "k," maximally reinforcing a verbal description of "press very fast" for key "a" and "press very slowly" for key "k." The verbal description point values were higher in this procedure than in Experiment 1 to balance the increase in points available on the schedule.

The procedure for this group differed from other groups in that the verbal descriptions and their associated point values were included in the pre-session 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 fast 180 pts
2. Press fast 144 pts
3. Press at a medium rate 108 pts
4. Press slowly 72 pts
5. Press very slowly 36 pts

The best way to earn ponts on key "k" is:

1. Press very fast 36 pts
2. Press fast 72 pts
3. Press at a medium rate 108 pts
4. Press slowly 144 pts
5. Press very slowly 180 pts

Data were collected until mean sessional response rates for each key were stable (three consecutive sessions with a range of >3 responses/5.5 s) or until subjects had fulfilled their obligation for experimental credit.

Results

The dependent measures were identical to those of Experiment 1, save that, due to the nondifferential nature of the schedules in Experiment 2, no PWR values were calculated.

Figure 5 shows the mean sessional response rate and the total verbal description points for keys "a" and "k" across sessions for Subject 5. The MaxPA verbal description was consistently chosen by Session 3 with the exception of Session 4 for key "a." Visual inspection of Figure 5 reveals considerably higher mean sessional response rates for key "k" than for key "a" in Sessions 2-4 with a steady decrease in this difference across sessions, due to a decreasing response rate on "k." The response rate for "k" continued to decline until response rates for the two keys were virtually identical, and very low (1 response/interval). Apparently, differential discriminative control by the verbal descriptions was transiently evidenced in Sessions 2 and 3, with the schedule competing successfully for control of response rate in Sessions 4-8. By session 8 the response rate was maximally efficient with respect to earning points on the schedule (1 response/interval being the most efficient).

Figure 6 shows the sessional dependent measures data for Subject 6. The MaxPA verbal description was consistently chosen by Session 3. Visual inspection of Figure 6 reveals a considerably higher mean sessional response rates on key "k" than key "a" in Session 2, with "a" rates slightly higher (by approximately 3 responses/interval) in Sessions 3 and 4. Thereafter, response rates on the two keys were similar, and by

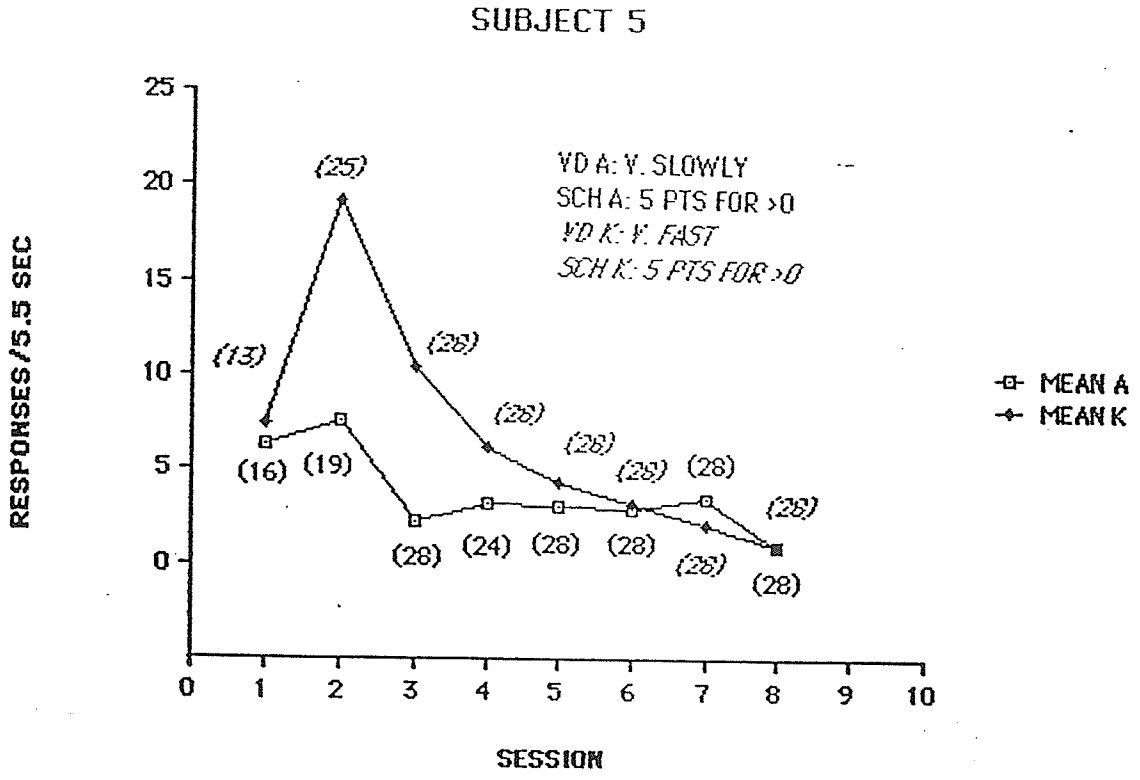

Figure 5. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 5. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

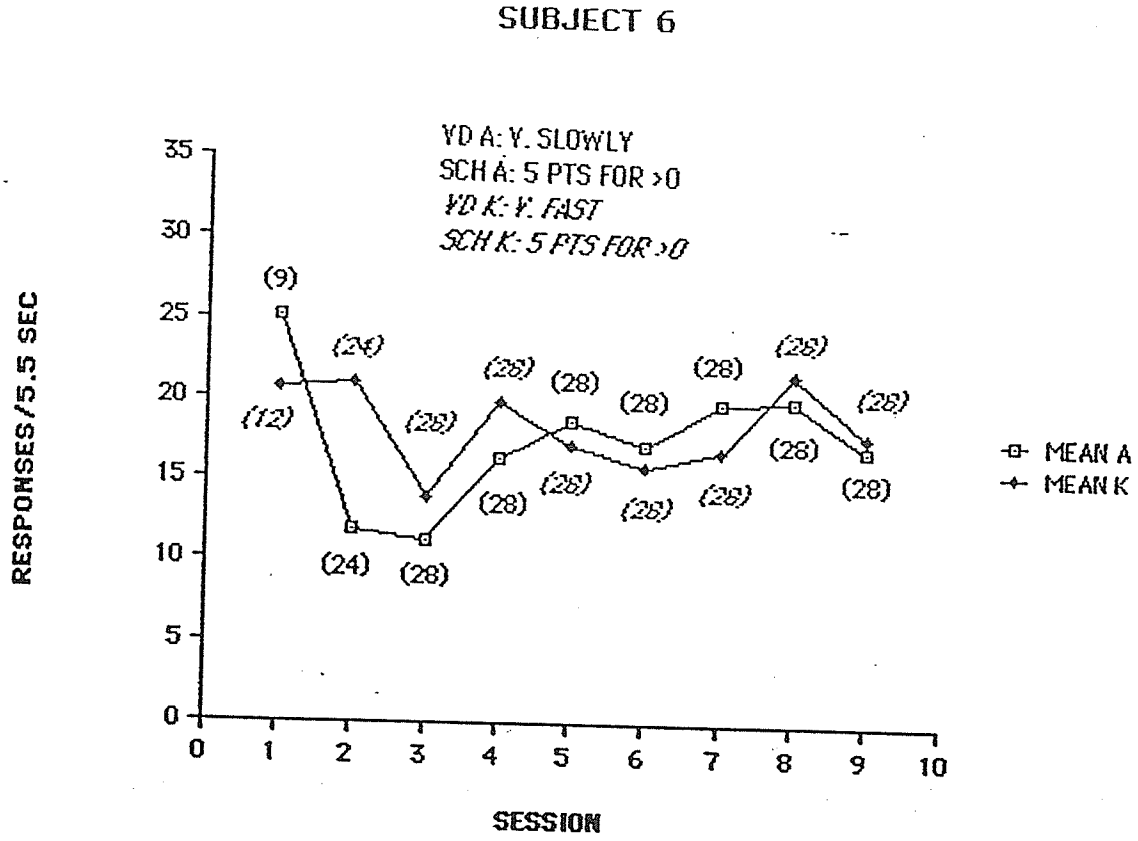

Figure 6. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 6. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

Session 9, nearly identical. Unlike Subject 5 the terminal rate of responding was still quite high (in the "fast" range). Indeed, the early verbal control of response rate appeared primarily due to the temporary decrease of response rate on key "a" (associated with the verbal description "press very slowly"). As with Subject 5 the differential discriminative control of the verbal descriptions over response rate was transient.

Figure 7 shows the sessional dependent measures data for Subject 7. The MaxPA verbal description was consistently chosen by Session 7. Visual inspection of Figure 7 reveals a trend of higher mean sessional response rates on key "k" than for key "a" in Sessions 3-6. This difference became most pronounced when full points were earned for verbal descriptions (Sessions 7 and 8). Discriminative verbal control persisted longer than in Subjects 5 and 6 until, abruptly, response rates for each key dropped and became very similar (at approximately 2.5 responses/interval). Again, differential discriminative control by the verbal descriptions appeared transient, with the low terminal rate of responding indicating schedule control.

Figure 8 shows the sessional dependent measures data for Subject 8. The MaxPA verbal descriptions were consistently chosen by Session 2. Visual inspection of Figure 8 reveals very low and approximately equal mean sessional response rates in all sessions save Sessions 3 and 4. Response rate was considerably higher for both keys in Sessions 3 and 4 than in all other sessions, though still similar between keys.

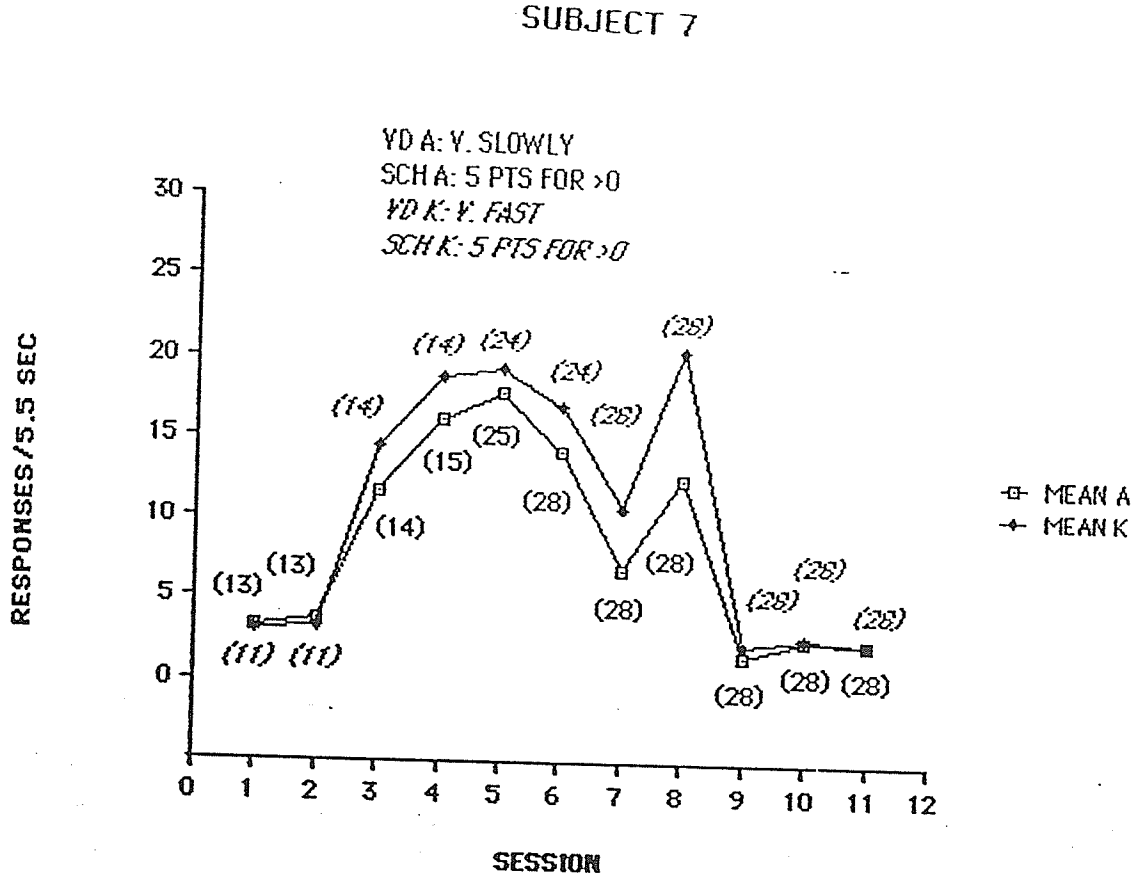

Figure 7. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 7. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

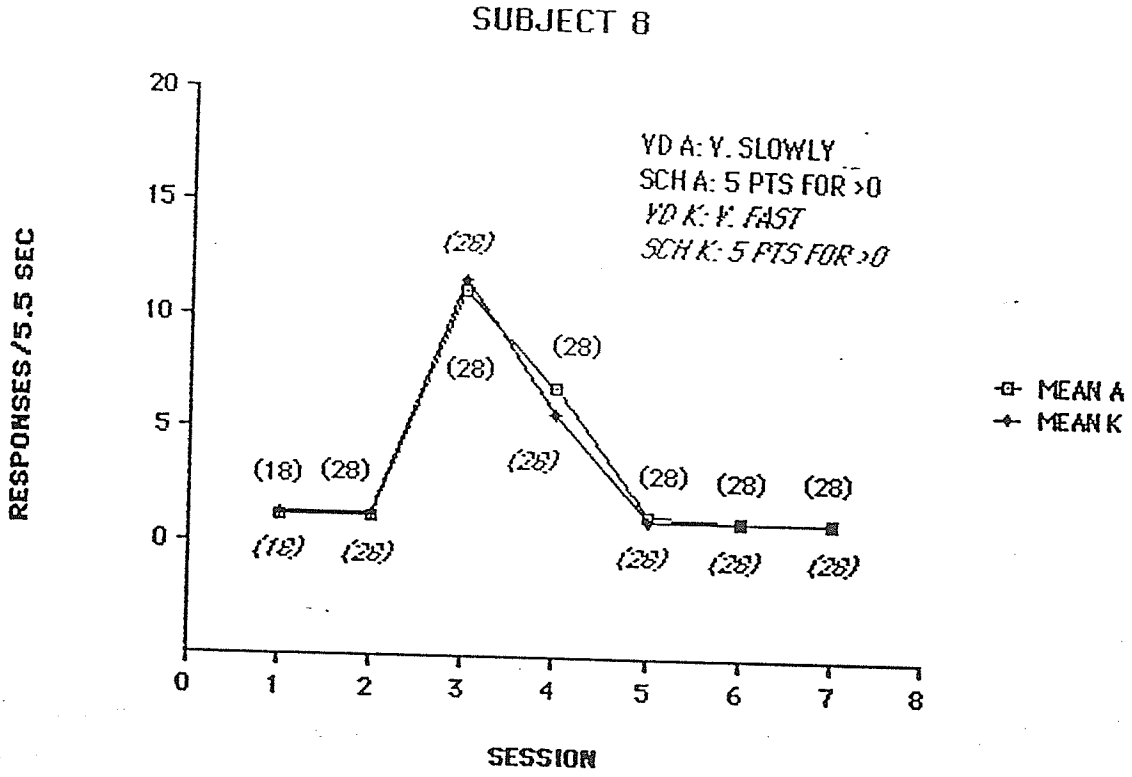

Figure 8. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 8. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

Differential discriminative control by the verbal descriptions appears absent from all sessions, with schedule control fully manifested in Sessions 5-7. Response rate was a constant 1/interval in Sessions 6 and 7, indicating efficient responding on the schedule.

Figure 9 shows the sessional dependent measures data for the first random subject, Subject 9. The MaxPA verbal description was consistently chosen during all sessions with the exception of Sessions 3 and 9 which each contained 1 error (resulting in the loss of four points). Visual inspection of Figure 9 reveals higher mean sessional response rates for key "a" than for key "k" in Sessions 2-4, indicating differential discriminative verbal control. Response rates declined on both keys following Session 5, becoming uniformly low and equal after Session 8. As in Subjects 5 and 7, initial differential discriminative control by the verbal descriptions gave way to efficient responding on the schedule across sessions.

Figure 10 shows the sessional dependent measures data for Subject 10. The MaxPA verbal description was consistently chosen during all sessions with the exception of the first. The single error on each key in Session 1 occurred after the first key pressing segment for each key. Visual inspection of Figure 10 reveals highly variable mean sessional response rates which are approximately equal across keys in all sessions. A decreasing trend is evident, with response rate considerably higher in three of the first four sessions (1, 3, 4) than in three of the last four sessions (5, 7, 8). These results parallel closely those of

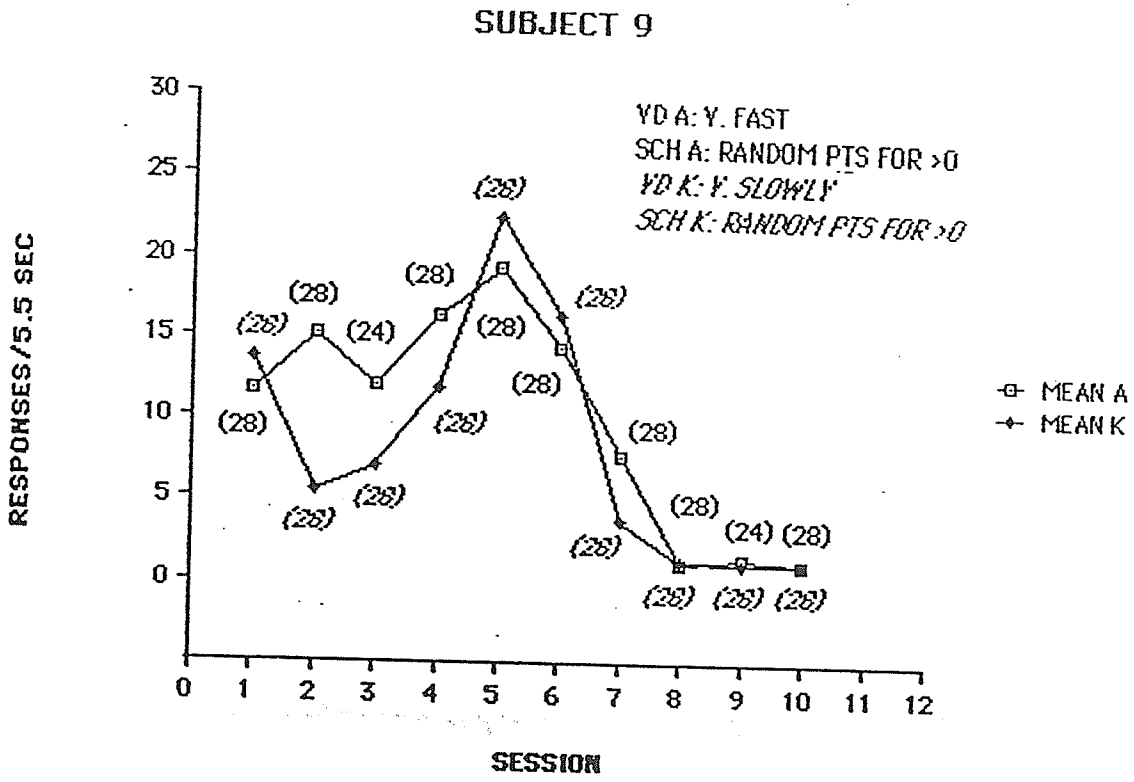

Figure 9. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 9. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

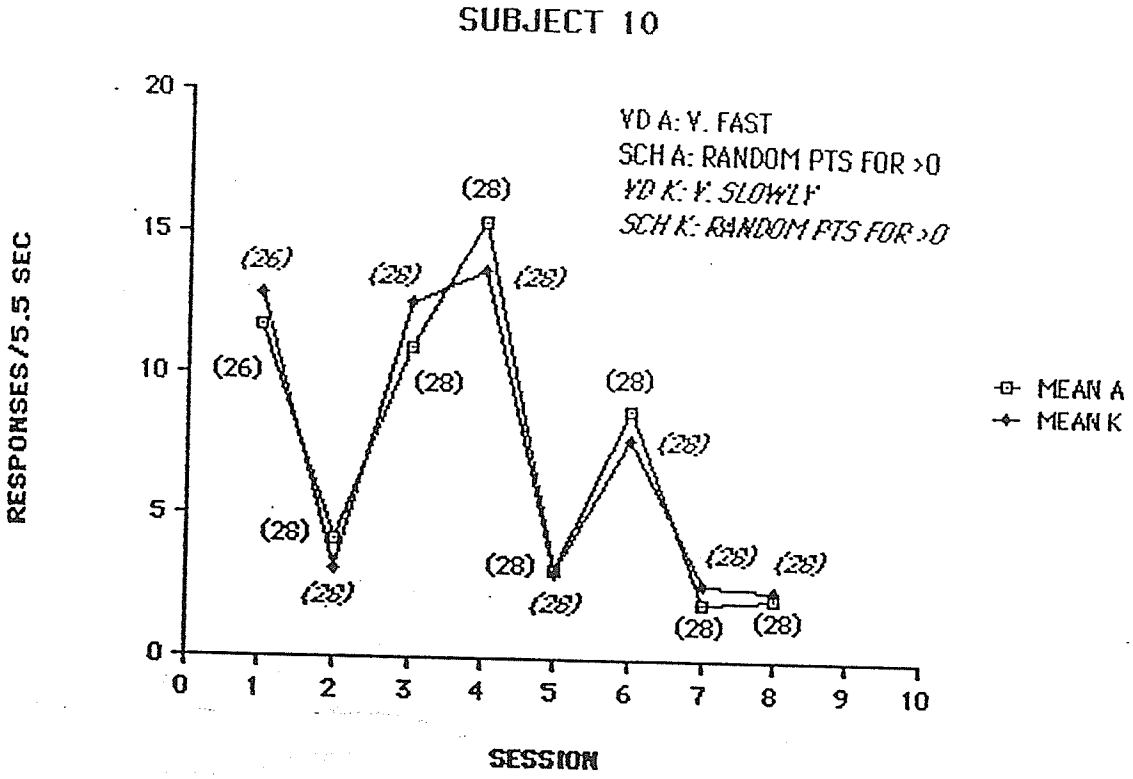

Figure 10. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 10. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

Subject 8, indicating an absence of discriminative control by the verbal description giving way to efficient responding on the schedule by the final two sessions.

Figure 11 shows the sessional dependent measures for Subject 11. The MaxPA verbal description was consistently chosen during all sessions. Visual inspection of Figure 11 reveals consistently higher mean sessional response rates on key "a" than on key "k" during all sessions, indicating strong differential discriminative control by the verbal descriptions. An increasing trend is evident in the key "a" response rate in Sessions 1-4. Key "k" exhibits a similar trend until Session 3. Verbal control was consistently demonstrated for Subject 11, as distinct from the transient control seen in Subjects 5, 6, 7, and 9, and generated greater rate differences between keys.

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 manifest itself initially but disappear over time (Subjects 5, 6, 7, and 9), or may not be demonstrated (Subjects 8 and 10).

It is important to note that the rate of pressing on both keys was very low by the end of the study in subjects who either did not come under verbal control or in whom verbal control was gradually lost (the exception being Subject 6). This result seems to indicate that persistent

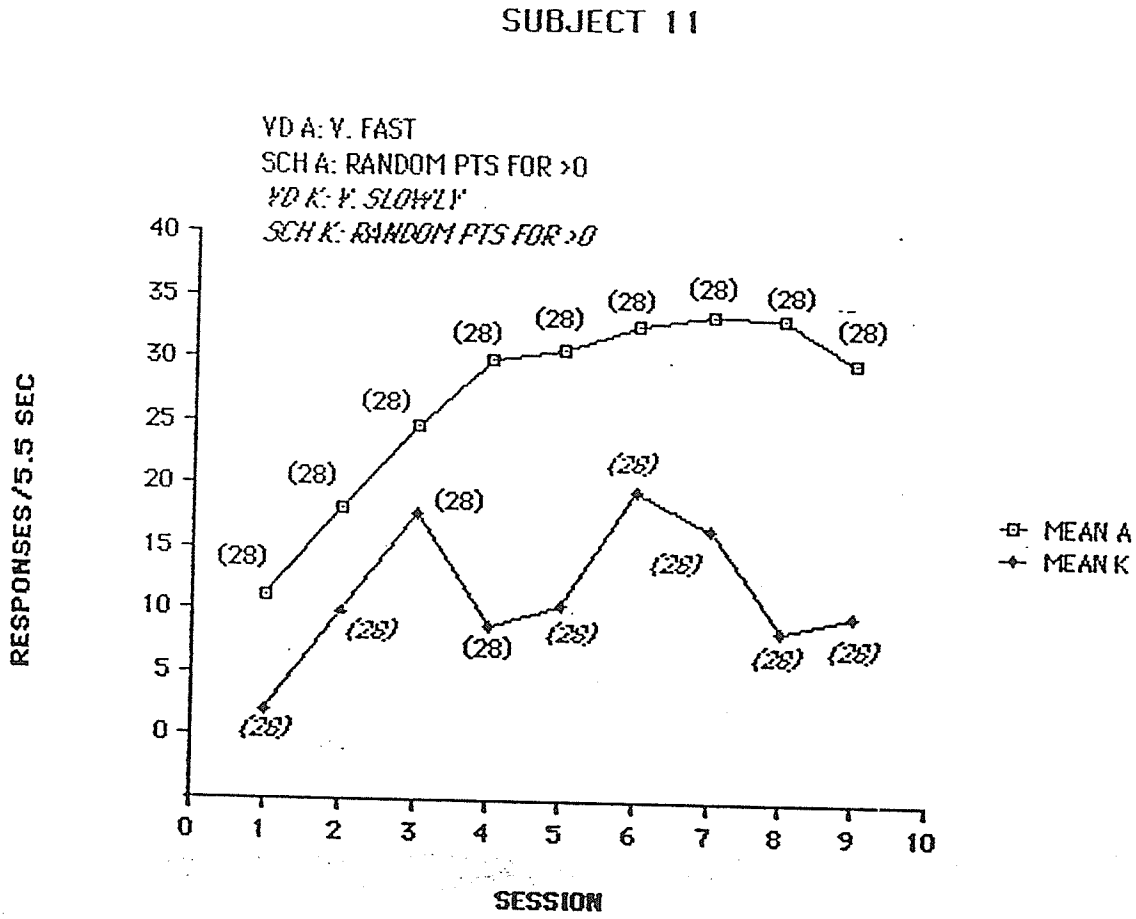

Figure 11. Mean sessional response rates (open and filled circles) and number of verbal description points earned in session (numbers in parentheses) for Subject 11. Numbers in plain type refer to key A, italicized numbers refer to key K. The letters VD and SCH in phase labels indicate the maximally reinforced verbal description and active schedule, respectively, for each key (A and K).

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 the active schedule. In the present case "contact" with the schedule may only mean varying the response rate during a given session sufficiently to abstract 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. The 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 discriminative 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/interval for key "a" and 19.2 responses/interval for key "k," indicating the expected verbal control. These data bely the fact that key individual interval rates for key "a" had a standard deviation of 6.34 with a sessional range of 0-30. Key "k" individual interval rates had a standard deviation of 9.86 with a sessional range of 0-33. Given that the number of points earned did not vary systematically with this great variability in response rate,

"contact" with the nondifferential consequences of the schedule might be said to have occurred.

Two subjects (8 and 10) demonstrated an absence of differential discriminative control by the verbal description from the initial session. For Subject 10, this result is easily accounted for by the extremely variable response rates demonstrated by this subject from the outset of the study (The ranges for the initial key presentations of the first session were 6-31 responses/interval for key "a" and 4-29 for key "k."). Discriminative control by the verbal description may have been invalidated by the nonsystematic variation in point presentation, irrespective of pressing rate. For Subject 8, the first session consisted entirely of individual interval response rates of 0-3 responses/interval for both keys. This subject may have quickly abstracted that an identical number of points were delivered for the two keys following each interval for this uniformly low response rate. Subsequently, when verbal descriptions were successfully shaped later in Session 1, they were less likely to exert discriminative control. Of course it was still possible that an increase in response rate would have produced more points on one or both response keys, hence, increased rates were explored by the subject in Sessions 3 and 4 before returning to a more efficient response rate in Session 5.

Subject 11 demonstrated clear differential discriminative 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. Beginning in Session 4, when verbal control began to promote very large rate differences between the keys, within-session variability indeed became very low (e.g., Session 8, Key "a" range: 30-37; Key "k" range 7-10). Variability had been considerably higher in the previous three sessions. These results seem to indicate that, unlike other subjects in Experiment 2 in 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.

An argument can also be made, however, for initial low variability producing verbal control in Subject 11, by analysis of individual key presentation data. Unlike other subjects, for whom response-rate variability was great within a single key presentation, Subject 11 showed little variability within single key presentations. High sessional variabilities in Sessions 1-3 derive mainly from differences in rate across key presentations. This low response-rate variability within a key presentation would decrease the likelihood of disciminating that changes in response rate have no effect on point presentation, because response-rate changes would have to be discriminated over a long period of time (from one key presentation to its next presentation). For other subjects, easily discriminated response-rate changes often occurred between immediately juxtaposed 5.5 s intervals of a single key presentation.

All subjects in Experiment 2 indicated in the post-study questionnaire that they became aware of the lack of correspondence

between pressing rate and schedule points during the course of the study. Subject 11 stated such awareness as well, indicating that the verbal descriptions were able to control response rate, even when this subject was able to verbalize contact with the schedule. According to Hayes, Brownstein, Zettle, et al. (1986), rule-governed behavior can be divided into two classes: (a) behavior which follows a rule because of a past history of correspondence between the rule and natural contingencies, and (b) behavior which follows a rule because of a past history of social reinforcement for following rules. The former rule-following is termed tracking; the latter is termed pliance. Given awareness of the irrelevance of the verbal descriptions as guides for responding, the rule following exhibited by Subject 11 may be an instance where the discriminative control of the rule is maintained through its action as a ply.

Experiment 3 sought to further enhance the discriminative control of the verbal description and to investigate whether contact with the active schedule, whether differential or nondifferential, was important in eliminating verbal control. In this study an attempt was made to introduce verbal control consistent with the scheduled contingencies and then to change the contingencies such that adherence to the verbal description would prevent contact with the new opposing contingencies. Contact with actual key pressing contingencies consonant with the verbal description would increase the discriminative control of the verbal descriptions in two ways. First, contingency contact would

provide a history of correspondence between description and schedule, thus increasing the description's discriminative validity as an indicator of appropriate response rate. To the extent that the schedule represents a natural contingency, this correspondence would promote the action of the verbal description as a track. Second, contact with the contingency would reduce variability in response rate, thus decreasing the likelihood of contact with the new opposing set of contingencies. In addition, Experiment 3 sought to determine whether exposure to consonant contingencies would enhance discriminative verbal control over response rate under a nondifferential contingency. It was demonstrated in Experiment 2 that such control was variable and, with one exception, transient.

Experiment 3

Method

Subjects. Three female students and one male student served as participants in Experiment 3.

Design. All subjects experienced an initial phase in which very rapid response rates on the "a" key received maximum points, and in which maximum points were provided for completing the sentence stem describing key "a" as "press very fast." Concomitantly, a very slow response rate received the most schedule points on key "k", while maximum points were provided for completing the sentence stem describing key "k" as "press very slowly." Following the achievement of a stable response rate on each key, two subjects received a condition in

which the verbal descriptions were unchanged, but the points received for actual presses was the same regardless of rate. Subsequently, following a stable response rate in the previous condition, the contingencies were changed such that key "a" provided maximum for very slow response rates while key "k" provided maximum points for very fast response rates. Two other subjects immediately experienced contingencies opposing the verbal descriptions after the maintenance of a stable response rate in the first condition. These procedures would demonstrate the extent of discriminative verbal control under both nondifferential and opposing contingencies, given a history of correspondence between description and schedule.

Procedure. The third experiment contained two similar procedures, each involving multiple phases. Two subjects experienced key pressing contingencies of 5, 4, 3, 2, 1 for key "a," maximally awarding points for a very fast rate of responding, and key pressing contingencies of 1, 2, 3, 4, 5 for key "k," maximally awarding points for a very slow rate of responding. Coincident with these key pressing contingencies were verbal description contingencies of 60, 48, 36, 24, 12 for key "a," maximally awarding points for a description of "press very fast", and verbal description contingencies of 12, 24, 36, 48, 60 for key "k," maximally awarding points for a description of "press very slowly." Following the achievement of response rate and verbal description stability criteria, which were the same as described earlier, response-rate contingencies were changed to 5, 5, 5, 5, 5 for both keys,

thus setting up a nondifferential contingency on response rate. Verbal description contingencies remained unchanged. The point value of "5" was chosen because subjects under schedule control in the previous phase would consistently receive that number of points. Institution of a nondifferential schedule employing a different constant point award would represent an obvious change in the contacted schedule contingencies. Following the achievement of both sets of stability criteria, response-rate contingencies were changed to 5, 6, 7, 8, 9 for key "a," and to 9, 8, 7, 6, 5 for key "k." Verbal description contingencies remained unchanged; therefore, the actual contingencies on key pressing were set in opposition to the verbal description of optimal pressing rate. Despite this opposition, however, response rates remaining within the previously MaxPA range would not contact the new opposing contingencies.

Two subjects experienced the same initial phase as subjects described above. Following the achievement of response rate and verbal description stability criteria, key pressing contingencies were changed to 5, 6, 7, 8, 9 for key "a," and to 9, 8, 7, 6, 5 for key "k." The verbal description contingencies remained unchanged for the two keys. Thus, the actual contingencies on key pressing were set in opposition to the verbal description of optimal response rate.

Results

Figure 12 shows the mean sessional response rate, PWR values, and the total verbal description points for keys "a" and "k" across sessions

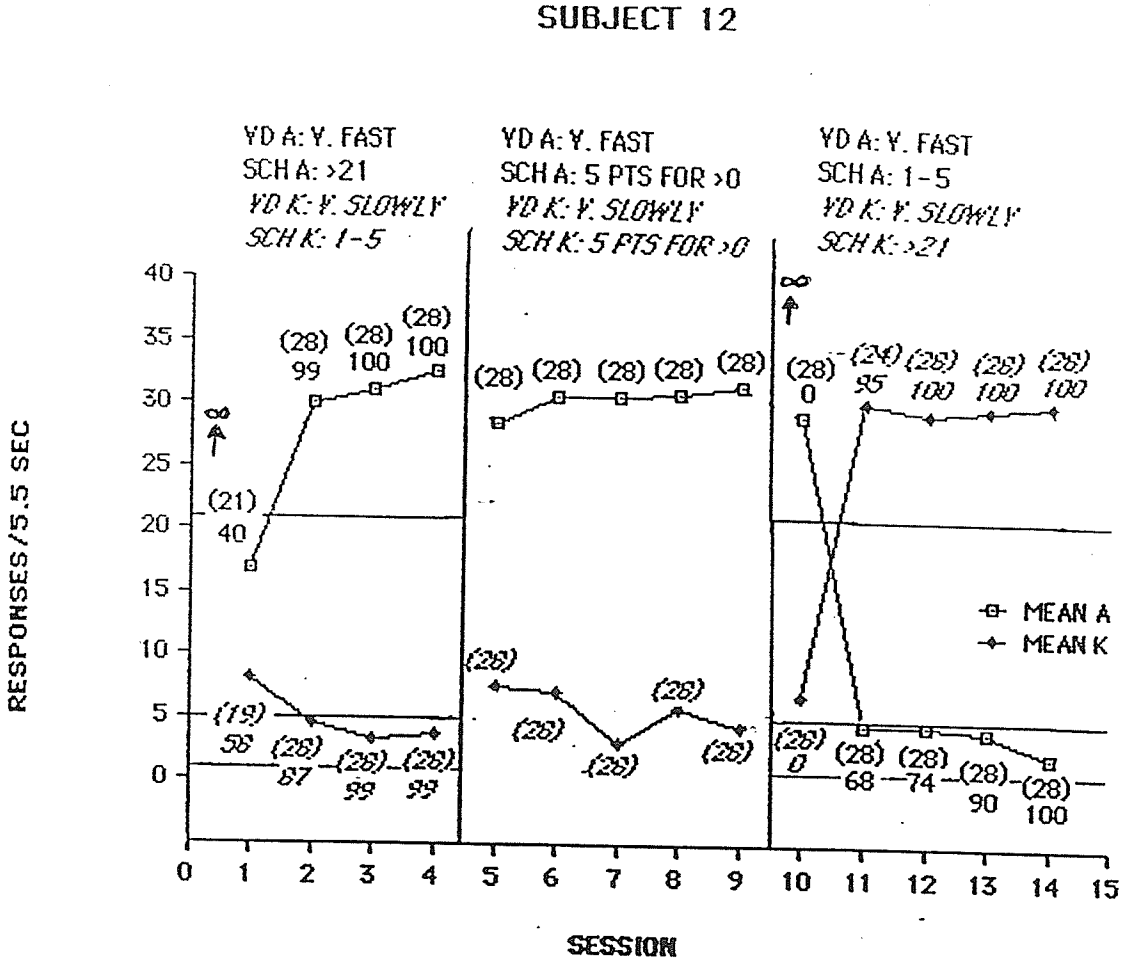

Figure 12. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 12. Numbers in plain type 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 (A and K).

for Subject 12. From Sessions 2-4, mean sessional response rates were consistently within the MaxPA ranges of 1-5 responses/interval for key "k" and >21 responses/interval for key "a," all with PWR values above criterion. The MaxPA verbal desciptions of "press very fast" for key "a" and "press very slowly" for key "k" were chosen consistently in all sessions for both keys except for Session 1 (both keys) and Session 11 (key "k" only). During Sessions 5-9, in the absence of a differential contingency, mean response rates remained stable and high on key "a" while remaining stable and low on key "k." The "k" mean response rates for Sessions 5, 6, and 8 are outside the boundaries of the former MaxPA range, however, indicating a slight rise in response rate. In general, however, differential discriminative control of response rate by the verbal description was maintained. During Sessions 10-14 the contingencies were reversed such that they opposed the verbal description. Mean sessional rates for keys "a" and "k" remained closely consistent with the former MaxPA ranges for Session 10, indicating verbal control, before moving into the new MaxPA ranges for Sessions 11-14, indicating discriminative control by the opposing schedule.

Table 1 shows Subject 12's individual interval pressing rates during Session 10. Cycle seven shows pressing rates beginning to conform to the contingencies established in Session 10. Table 2 shows the continuation of this trend in Session 11. Boxed-in rates indicate large rate changes associated with schedule contact.

Table 1

Subject 12's Individual Interval Response Rate Data for Session 10.

Results for key: a

Cycles ==>	1	2	3	4	5	6	7
Interval							
1	29	28	23	28	30	23	29
2	36	36	32	32	31	29	21
3	34	34	31	34	31	30	11
4	33	36	29	33	31	31	13
5	34	32	31	31	33	30	12
6	38	31	24	31	31	30	12
7	35	27	40	29	32	30	14
8	31	29	38	33	30	31	9
9	31	29	32	35	32	29	10
10	30	31	36	33	36	29	12
11	32	29	32	28	34	36	11
12	32	29	31	31	33	37	12

Results for key: k

Cycles ==>	1	2	3	4	5	6	7
Interval							
1	5	4	4	4	4	3	10
2	4	2	4	4	6	4	12
3	2	5	6	5	8	6	13
4	2	3	6	7	5	4	12
5	1	8	3	10	10	6	12
6	3	2	4	5	5	7	13
7	1	3	5	12	9	10	13
8	2	4	5	7	6	6	14
9	2	2	7	6	9	9	13
10	3	6	8	9	10	9	14
11	3	3	4	8	5	10	14
12	7	5	15	7	8	10	15

Note. Each number in all sessional data tables represents the number of responses for one 5.5 s interval (12 intervals/key presentation).

Table 2

Subject 12's Individual Interval Response Rate Data for Session 11.

Results for key: a

Cycles ==>	1	2	3	4	5	6	7
Interval							
1	3	4	2	3	2	4	5
2	3	3	2	6	2	7	6
3	1	3	1	5	4	4	7
4	2	3	2	6	2	3	8
5	2	3	3	4	5	10	7
6	4	3	3	4	6	7	8
7	3	1	2	3	3	9	10
8	3	3	2	7	5	5	10
9	2	4	2	3	6	7	10
10	3	4	2	6	3	12	9
11	2	3	3	3	4	7	8
12	5	3	3	3	5	9	11

Results for key: k

Cycles ==>	1	2	3	4	5	6	7
Interval							
1	6	23	28	29	29	28	23
2	6	28	32	33	35	34	33
3	10	27	35	32	32	32	32
4	10	27	34	30	31	34	31
5	14	34	35	32	34	33	31
6	21	29	32	31	32	30	30
7	24	31	32	30	32	32	29
8	29	30	33	30	33	32	29
9	31	31	30	31	33	34	30
10	32	30	35	32	33	31	31
11	32	30	33	32	30	32	30
12	32	30	33	31	32	29	33

Figure 13 shows the sessional dependent measures data for Subject 13. From Sessions 1-4 for key "a," and in Sessions 2-4 for key "k," mean sessional response rates were consistently within the MaxPA ranges of >21 responses/interval for key "a" and 1-5 responses/interval for key "k," all with PWI values above criterion. The MaxPA verbal descriptions of "press very fast" for key "a" and "press very slowly" for key "k" were consistently chosen in all sessions except Session 1 (although Session 1 values still reached criterion). During Sessions 5-9, in the absence of a differential contingency, mean sessional response rates remained uniformly high for key "a" and uniformly low for key "k," all within the boundaries of the former MaxPA range. When the MaxPA range was opposed to the MaxPA verbal description from Sessions 10-15, mean sessional response rates remained high for key "a" and low for key "k," with consistently zero PWI values, consistent with the MaxPA verbal description. Differential discriminative control by the verbal description was maintained throughout both the nondifferential and opposing schedule phases.

Table 3 shows Subject 13's individual interval response rates during Session 12. These data show occasional contact on key "k" with the contingencies established in Session 10 without response rate conforming to the new schedules. Specifically, although response rate occasionally exceeded 5 responses/interval, with a corresponding increase in the number of points earned in those intervals, the mean sessional response rate remained within the range that had previously received the most points (1-5).

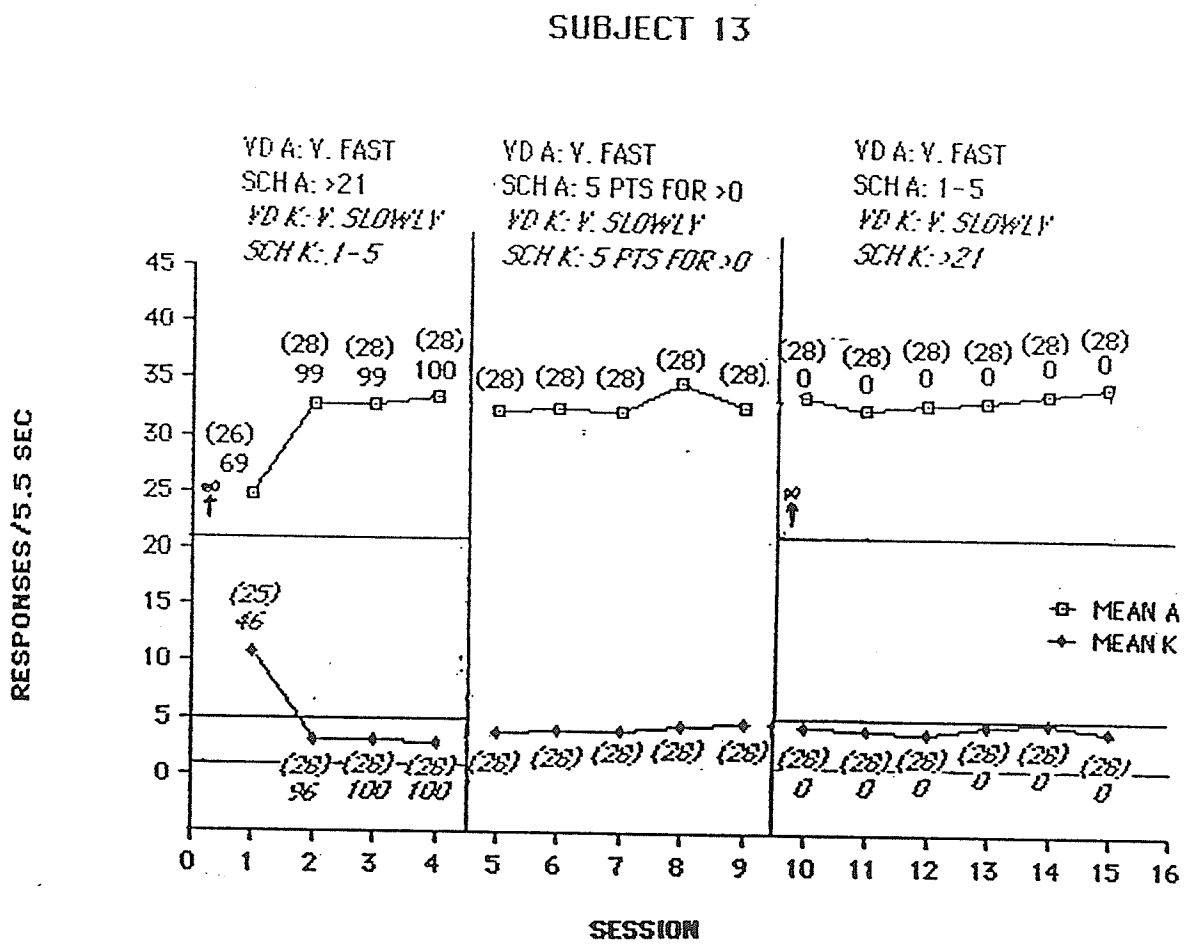

Figure 13. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 13. Numbers in plain type 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 (A and K).

Table 3

Subject 13's Individual Interval Response Rate Data for Session 12.

Results for key: a

Cycles ==> / Interval	1	2	3	4	5	6	7
1	28	26	32	29	29	23	28
2	36	33	35	34	36	35	36
3	35	33	33	34	35	34	35
4	33	32	35	32	34	33	33
5	34	32	35	32	35	32	31
6	33	31	35	32	34	36	34
7	34	31	34	32	35	34	34
8	33	31	34	32	34	34	31
9	32	30	32	32	33	34	31
10	32	31	34	31	34	34	31
11	32	30	34	31	35	33	31
12	33	30	33	30	33	34	32

Results for key: k

Cycles ==> / Interval	1	2	3	4	5	6	7
1	5	[7]	[9]	5	5	5	[8]
2	4	5	[6]	3	4	4	4
3	3	5	3	4	5	4	4
4	4	[8]	3	3	4	4	[7]
5	4	5	[6]	4	[6]	3	4
6	4	2	4	3	4	2	4
7	2	4	4	3	4	5	4
8	5	4	3	4	5	4	4
9	[6]	5	5	3	3	4	[7]
10	4	3	5	4	3	4	3
11	3	4	3	2	[6]	4	5
12	3	[6]	5	4	3	4	3

Figure 14 shows the sessional dependent measures data for Subject 14. During Sessions 1 and 2 mean sessional response rates were outside the MaxPA range, PWR values were low, and verbal description points were below criterion. In all subsequent sessions the subject consistently chose the MaxPA verbal description of "press very fast" for key "a" and "press very slowly" for key "k." From Sessions 3 to 11 mean sessional response rates were all within the MaxPA range (>21 for key "a"; 1-5 for key "k"). PWR values reached criterion by Session 5 for key "a" and Session 3 for key "k." During Sessions 5-8, however, PWR values for "k" decreased to well below criterion because of several intervals in which zero key presses occurred. Beginning with Session 9, zero-response intervals completely disappeared and criterion was achieved for Sessions 9-11. Response-rate contingencies were changed in Session 12 to directly oppose the verbal descriptions. In Sessions 12 and 13 mean sessional response rates remained in the minimally point-awarded response-rate range, indicating discriminative control by the verbal descriptions. PWR values were near zero. Beginning in Session 14, mean response rates moved quickly toward the MaxPA range, indicating increasing discriminative control by the schedule. PWR values increased markedly, but only reached criterion in Session 15 for key "a" and in Session 17 for key "k."

Table 4 shows Subject 14's individual interval response rates for both keys during Session 13 in which contact with the opposing schedule first occurs. The fifth 5.5 s interval of cycle six reveals the first

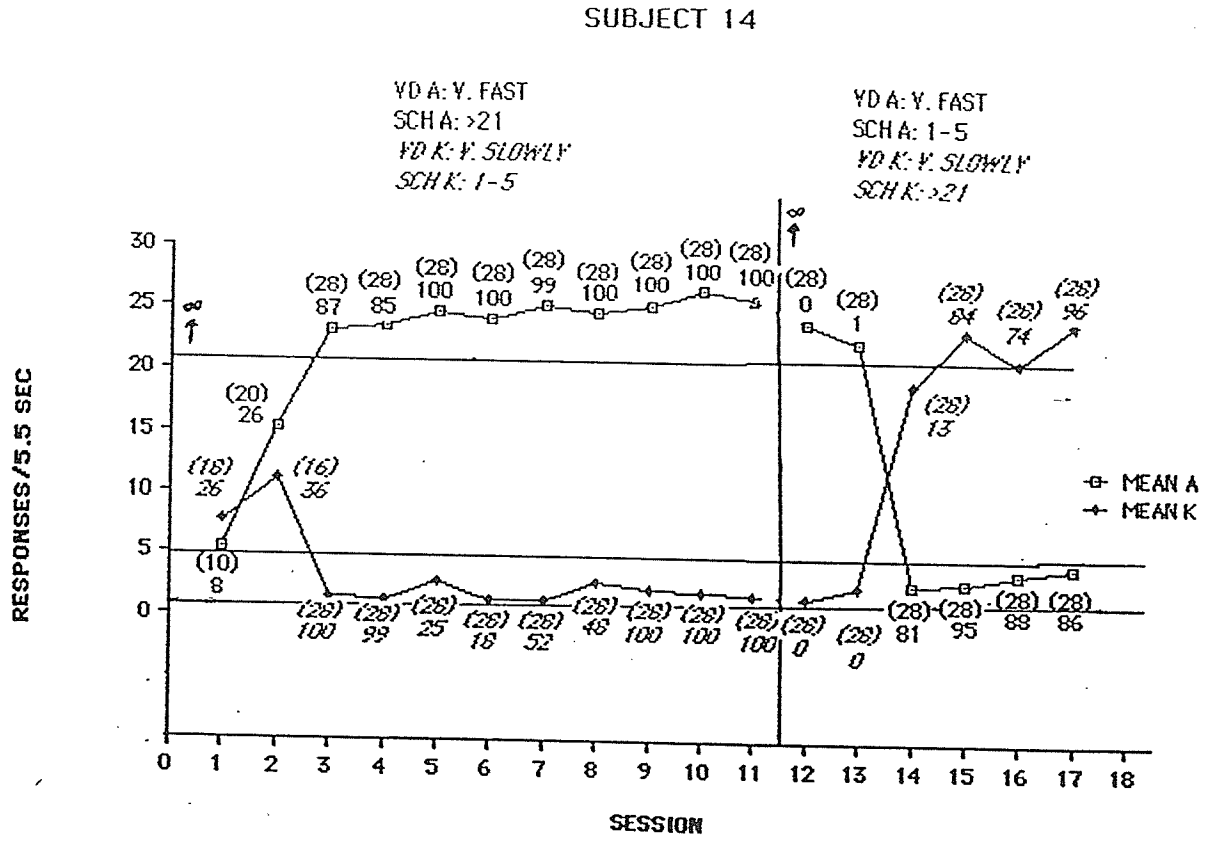

Figure 14. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 14. Numbers in plain type 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 (A and K).

Table 4

Subject 14's Individual Interval Response Rate Data for Session 13.

Results for key: a

Cycles ==> / Interval	1	2	3	4	5	6	7
1	16	24	23	21	23	21	19
2	31	25	25	24	25	24	23
3	28	26	25	23	26	23	21
4	26	24	25	25	26	22	20
5	25	25	24	24	25	20	15
6	26	24	25	24	25	20	15
7	25	25	24	24	25	17	12
8	25	24	24	24	25	18	8
9	25	26	26	24	23	17	8
10	25	24	26	22	25	19	6
11	25	25	27	24	25	17	5
12	24	24	26	23	24	16	7

Results for key: k

Cycles ==> / Interval	1	2	3	4	5	6	7
1	1	2	2	2	2	3	8
2	2	2	1	2	3	2	10
3	1	1	2	2	2	3	6
4	1	2	1	2	2	2	3
5	1	2	1	2	3	2	4
6	2	2	2	2	2	2	5
7	2	2	1	2	2	2	5
8	1	2	2	2	2	2	3
9	2	2	2	3	2	2	7
10	2	2	2	2	3	2	7
11	1	2	2	2	2	2	10
12	2	2	2	2	2	2	11

contact with the opposing contingency. Cycle seven reveals response rates moving outside the previously MaxPA range and toward the new contingencies established in Session 12. This trend continues in Session 14 (Table 5).

Figure 15 shows the sessional dependent measures data for Subject 15. During Sessions 1-9, mean sessional response rates were outside the MaxPA range for "a" (except for Session 6) of >21 responses/interval, indicating poor control by the schedule. Initial mean sessional values for "k" were generally outside the MaxPA range of 1-5 responses/interval (except for Session 1) before moving consistently within the range from Sessions 6-9. PWR values were low and variable for key "a." PWR values for "k" were low until reaching criterion in Session 6. Schedule "k" appeared to exert more precise control over responding than schedule "a." The lower "k" PWR values of Sessions 7-9 reflect an increasing number of zero-response intervals.

Verbal description values were variable, with the MaxPA key "a" description of "press very fast" consistently chosen for in Sessions 5, 6, and 9, while the MaxPA key "k" description of "press very slowly" was consistently chosen in Sessions 5, 8, and 9. Due to time constraints on subject participation, opposing contingencies were introduced prior to Subject 13 achieving full phase-shift criteria. In Sessions 10-15, verbal description values continued to be variable, reaching criterion only in Sessions 10-12 for key "a" and in Sessions 10 and 11 for key "k." The subsequent low verbal description values (Sessions 12-15) appeared to

Table 5

Subject 14's Individual Interval Response Rate Data for Session 14.

Results for key: a

Cycles ==> / Interval	1	2	3	4	5	6	7
1	15	1	1	1	1	1	1
2	3	3	1	1	1	5	1
3	4	5	2	2	1	6	1
4	3	4	1	5	1	0	3
5	4	5	2	5	1	0	2
6	0	5	3	4	1	3	4
7	0	5	4	3	2	7	3
8	1	6	3	2	2	4	4
9	0	6	2	3	2	6	4
10	0	5	3	2	3	5	4
11	1	5	4	5	3	0	5
12	0	0	3	0	3	4	5

Results for key: k

Cycles ==> / Interval	1	2	3	4	5	6	7
1	12	12	15	12	7	14	15
2	12	17	20	20	21	20	22
3	16	18	20	18	19	20	20
4	18	17	20	20	20	20	19
5	19	17	20	19	20	18	22
6	16	18	20	19	20	20	21
7	17	18	19	20	19	20	21
8	16	16	21	18	19	19	20
9	15	18	18	17	18	19	26
10	17	19	20	18	17	19	28
11	16	19	19	18	18	20	26
12	16	19	18	18	18	18	27

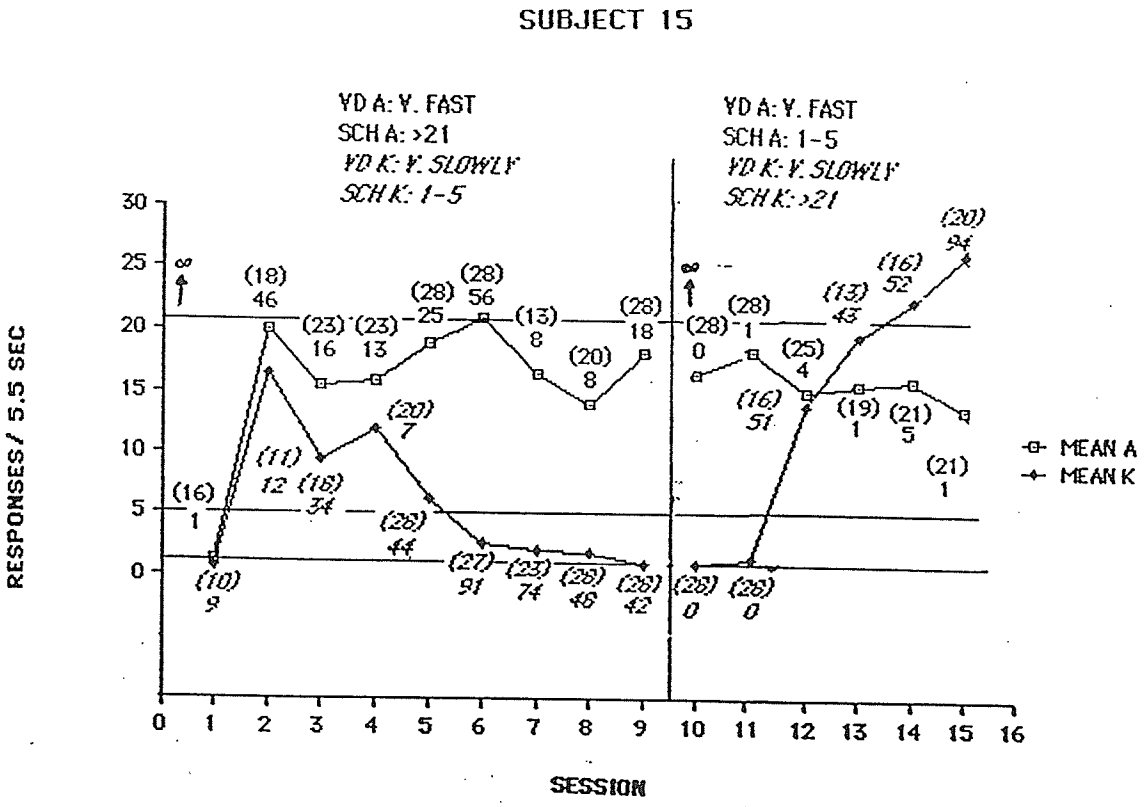

Figure 15. Mean sessional response rates (open and filled circles), percentage of 5.5 s intervals in session in which response rate fell inside the maximally reinforced range (numbers without parentheses), and number of verbal description points earned in session (numbers in parentheses) for Subject 15. Numbers in plain type 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 (A and K).

have been impacted by the contingency change. In particular, key "k," which evidenced the greatest move toward correspondence with the opposing contingency (in Sessions 12-15), received few verbal description points, indicating a tendency to describe that key in terms of the opposing contingencies. Mean sessional response rates for key "a" remained outside the MaxPA range (1-5 responses/interval) and PWR values remained low, indicating some limited verbal control.

Table 6 shows Subject 15's individual interval response rates for both keys during Session 12. Cycle three reveals pressing rates beginning to correspond to the contingencies established in Session 10 for key "k." This trend is continued in cycle four and maintained thereafter. Key "a" shows that the opposing contingency was extensively contacted by response rate without breaking verbal control of response rate.

Discussion

Experiment 3 demonstrated two main results. First, exposure to consonant contingencies and verbal descriptions produced maintenance of discriminative verbal control under the nondifferential contingency of 5, 5, 5, 5, 5. Second, verbal control was either maintained or lost in the presence of contact with the opposing contingencies, presumably depending on the conditions of that contact.

With respect to the maintenance of verbal control under nondifferential contingencies, this result differs markedly from that seen in Experiment 2 in which verbal control decayed rapidly. Much of

Table 6

Subject 15's Individual Interval Response Rate Data for Session 12.

Results for key: a

Cycles ==> / Interval	1	2	3	4	5	6	7
1	[8]	[7]	10	9	10	[4]	[5]
2	10	13	10	[0]	19	19	19
3	[7]	15	17	[0]	[7]	17	17
4	[6]	18	17	[4]	18	16	22
5	15	19	14	12	18	14	20
6	21	18	18	12	20	11	15
7	13	17	15	25	22	14	18
8	22	22	13	24	21	17	19
9	16	19	10	21	21	19	17
10	16	11	11	21	22	18	[0]
11	[2]	16	[8]	15	22	18	[0]
12	10	12	11	12	21	19	[3]

Results for key: k

Cycles ==> / Interval	1	2	3	4	5	6	7
1	7	2	7	3	12	18	19
2	0	0	1	18	22	24	21
3	3	0	0	22	23	21	23
4	0	0	0	26	23	24	21
5	0	0	0	26	24	25	20
6	2	0	3	24	24	22	17
7	0	0	0	25	23	26	18
8	0	0	0	27	24	24	23
9	2	0	4	25	22	24	23
10	0	1	[0]	27	20	22	23
11	5	0	[18]	25	24	21	21
12	0	0	12	24	21	21	22

this difference may be due to the tight response range established by experience with the consonant contingencies, thus bringing response rate under more precise discriminative control of the verbal descriptions. Particularly in Subject 13, response-rate ranges were very restricted and the standard deviations were small. Typical was Session 7 in which key "a" rates ranged from 28-35 with a standard deviation of 1.63 and in which key "k" rates ranged from 3-8 with a standard deviation of 0.86. Subject 12 demonstrated slightly larger ranges (Session 8: key "a," 27-37; key "k," 1-12) and standard deviations (Session 8: key "a" standard deviation=2.43; key "k" standard deviation=2.20), although both sets of values were much smaller than those typical of Procedure 2 subjects (e.g., Subject 5, Session 2, key "a:" range 0-30, standard deviation 6.34; key "k:" range 0-33, standard deviation 9.86).

There are two possible interpretations of the data based on the narrow response ranges established in the first phase. Prior experience with the differential contingency, not control by the rule, may have given the appearance of verbal control. Alternatively, experience with contingencies consonant with the rule may have enhanced the rule's discriminative control over response rate. A subsequent phase in which the verbal description was removed might reveal the relative strengths of schedule and rule in creating differential response rates. If response rates began to merge coincident with removal of the verbal description, discriminative verbal control would be implicated. The interpretation would be more difficult if response rates did not begin to merge

coincident with removal of the verbal description. Removing the verbal descriptions does not guarantee the elimination of discriminative verbal control of responding; consequently, persistent responding in accordance with the eliminated rule could reflect either the past history with the schedule or rule-governed behavior. Subjects might require explicit instructions that the MaxPA verbal description no longer applied to remove the discriminative verbal control of response rate.

The second major finding was that schedule contact was variable in breaking verbal control. For several subjects, contact with the opposing schedule rapidly eliminated verbal control. The Session 10 data for Subject 12 (Table 1) indicate that the first contact with the opposing contingencies (the first "11" in cycle 7 for key "a," it being the first response of <21 responses/interval) heralded an abrupt decrease in response rate. Contacts with the contingency on key "k" (i.e., > 5 responses/interval) can be seen to result in a gradual increase in response rate (particularly in cycles 5-7). The Session 13 data for Subject 14 (Table 4) indicate that repeated contact with the opposing contingency (beginning with the first "20" in cycle 6 for key "a") brought about a gradual decrease in response rate on this key. Soon thereafter (during cycle 7), the response rate on key "k" gradually increased. The finding is further supported by the Session 12 data for Subject 15 (Table 6). The "18" presses during cycle 3 for key "k" appear just prior to a large increase in response rate on this key.

Despite these examples of contingency contact breaking verbal control there are several instances in which contact is made without loss of verbal control. The closeup data for Subject 15 (Table 6), show numerous key "a" responses of <21 that contact the differential contingency for pressing very slowly. Despite this contact, and despite key "k" coming under control of the contingency, key "a" response rates did not decrease appreciably. The same result is evidenced by Subject 13 in Session 12 (Table 3). Several contacts of the opposing contingency occur for key "k" (i.e., >5 responses/interval), yet differential discriminative verbal control is maintained. This contact was maintained over several sessions for both subjects, without an appreciable difference in response rate. It appears that contingency contact alone is not necessarily sufficient to break discriminative verbal control.

In the present study the preexperimental instructions specify that "pressing rate" is of importance in earning points. Subjects are then either given a verbal description of how best to earn points (the second procedure of Experiment 2) or are allowed to contact contingencies reinforcing a particular performance description. In either case the information acquired about the relationship between key pressing and points constitutes a verbal rule. As we saw in the earlier discussion of past research, such rules have been demonstrated to promote insensitivity to changing schedules of reinforcement. Several theories explaining such insensitivity have arisen including : (a) that rules

generate patterns of responding that preclude effective contact with the schedules (Baron & Galizio, 1983), (b) that insensitivity is intrinsic to instructional control (Shimoff et al., 1981), and (c) that insensitivity can be due to additional sources of reinforcement, both social and nonsocial, involved in instructional control (Hayes, Brownstein, Zettle, et al., 1986). If we treat the verbal description of key pressing as a rule, each of these theories can be evaluated in terms of the present data.

The data for experiment 3 clearly rule out the maintenance of verbal control exclusively through lack of contact with counteracting contingencies ("precluded contact" theory). Verbal control was maintained even in the presence of opposing contingency contact in several instances. Neither can "instructional insensitivity" theory be considered as an all-encompassing explanation. Instructional control was broken in several instances due to contingency contact. Both theories may have some bearing on the present data, however, if we accept both in less absolute terms and assume that the frequency and nature of contingency contact are important in determining the relative discriminative control of schedule and verbal description. Thus, insensitivity will be demonstrated ("instructional insensitivity" theory) when the nature and frequency of contact with the schedule are insufficient to bring behavior under discriminative control of the schedule. Alternatively, when the nature and frequency of schedule contact are sufficient, discriminative verbal control will be broken ("precluded contact" theory). The "additional sources of reinforcement" involved in instructional control will be dealt with later.

With respect to the present study, "contacting the schedule" may be conceptualized in terms of the two forms of discriminations made by a subject while responding on the schedule. First, subjects may discriminate a change in the number of points received at 5.5 s intervals. Second, subjects may discriminate when they have changed their rate of responding. Clearly, a subject disciminating both that the number of points increased and that response rate was changed is in an excellent position to generalize that further rate changes may produce more points. In the final phase of Experiment 3 all subjects are responding on an opposing schedule in which small changes in response rate from those receiving maximum points in the initial phase would result in an increase in the number of points received. Changes in the point value received per interval may, or may not, be discriminated depending on the vigilance of the subject and the size of the point change. Whether changes in response rate are discriminated is likely to depend on whether the subject depends on proprioceptive feedback to guage the rate of responding or counts the number of responses emitted in an interval. In the former case in particular, only fairly large changes in response rate might be discriminable. Consequently, we might expect that contingency "contacts" (i.e., more points are earned on the schedule than in the previous interval because of a change in response rate) in which the change in rate is small may not undermine discriminative verbal control. Similarly, persistent contact with the schedule in the absence of large rate changes might take considerable time to exert

control over behavior. Alternatively, large rate changes would tend to preceed the establishment of schedule control, particularly in association with large changes in the number of points earned on the schedule. The results of the present study allow a preliminary evaluation of this hypothesis.

The data are generally consistent with the above hypothesis. Subject 12's (Table 1) first contact with the opposing schedule on key "k" (the 11 responses in cycle 7, interval 3) represents a large change in response rate from the previous interval (21 responses). So, too, is the change in response rate between the end of Session 10 (Table 1), and the onset of Session 11 (12 to 3 responses/interval; Table 2). On key "k" opposing schedule contacts were occasionally persistent (intervals 5-12 of cycle 6) and occasionally represented large changes in rate (e.g., from 4 responses/interval in interval 11 to 15 responses/interval in interval 12 of cycle 3). Not until interval 6 of cycle 1 in the subsequent session (Table 2), however, when response rate jumped from 14 to 21 responses/interval, did the opposing schedule achieve complete control of response rate. It should be noted that contact with the opposing contingency on schedule "a" (cycle 7 of Table 1) appeared at least partially responsible for a consistent change in response rate on key "k." Undoubtedly, the erosion of verbal discriminative control on one key would call into question the validity of the other verbal description as a guide for response rate.

Subject 14 (Table 4), persistently contacted the opposing schedule for key "a" in intervals 5-12 of cycle 6. Despite this contact, response rate did not move consistently in the direction dictated by the opposing schedule until the relatively large drop in interval 5 of cycle 7 (20 to 15 responses/interval). The large change in rate (15 to 3 responses/interval) in interval 2 of cycle 1 in the subsequent session (Table 5) immediately preceeded complete conformation of response rate to the opposing schedule. Key "k" rates made large changes between the end of cycle 6 and the onset of cycle 7 (Table 4). As in Subject 12, however, the increased response rate on key "k" appeared related to the decrease in response rate on key "a," indicating that the breaking of verbal control on one key may have a generalized effect on verbal discriminative control. As further support for the importance of a discriminable rate change in schedule control, it should be noted that in Session 14 (Table 5) several contacts with the range providing the maximum number of points on key "k" (>21responses/interval) were made during the session. Despite these contacts, response rate did not consistently conform to that range until the large rate change between intervals 8 and 9 of cycle 7 (20 to 26 responses/interval).

Subject 15 (Table 6) shows a marked change in rate on key "k" during interval 11 of cycle 3 (from 0 to 18 responses/interval). During the next cycle, responding came under control of the schedule. Here again, a large change in response rate appears implicated in breaking schedule control.

In contrast to the above results, Subject 13 did not contact the contingency on key "a" during any interval, and key "k" contacts did not represent large changes in rate (Table 3). According to the hypothesis expressed above, the erosion of verbal discriminative control would be much slower for this subject. It may be that continued exposure to the opposing schedule would eventually have broken verbal control. Indeed, in Session 14, two consecutive intervals showed response rates of 13 and 10 responses/interval, respectively. Response rates, however, immediately dropped to 5 or below for the majority of remaining intervals in that session. The prolonged history of low variability responding under verbal control may have rendered this subject less sensitive to changes in the schedule contingencies.

Subject 15's extensive contact with the opposing contingency on key "a" (Table 6) without coming under schedule control appears to contradict the above hypothesis. There are several possible explanations for this discrepant performance.

First, Subject 15 came under poor schedule control during the intitial phase of the study (PWR at the time of phase shifting was 18% for key "a" and 42% for key "k"). Verbal control would have a slight advantage in such a less schedule-sensititive subject. This explanation does not account, however, for key "k's" sensitivity to the opposing contingencies. Second, because of the variablilty of response rate on key "a," the subject would be receiving a varying number of points each interval. This contrasts markedly to fully schedule-controlled subjects

who receive 5 points following every interval. The varying number of points awarded to Subject 15 under consonant contingencies would make the change in awarded point values more difficult to detect. This explanation accounts for the susceptability of key "k" to control by contact with the opposing contingency. Despite coming under poor schedule control on key "k" by virtue of many zero-response intervals, such intervals do not add any points to the counter. When Subject 15 did respond on key "k," the response rate almost invariably earned 5 points. Consequently, the change in contingencies would be more detectable on key "k" than on key "a." Third, as seen in cycles 4 and 7 of Table 6 for key "a", decreases in response rate often continued to 0 responses/interval, for which no points would be awarded. This occurred several times during the first few sessions under contact with the opposing contingency. The earning of zero points might tend to move response rate back toward a rate consistent with the "press very fast" verbal description. Any or all of the above explanations may have been operative to keep key "a" under verbal control.

General Discussion

Comparing the present data with those of previous researchers (Catania et al.,1982; Hayes, Brownstein, Zettle 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 employed.

With reference to schedule clarity, the Catania et al. (1982) and Matthews et al.(1985) data indicate poor control by the schedule in the absence of verbal rules. The same can be said for the Hayes, Brownstein, Zettle et al. (1986) 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, by contrast, demonstrated precise discriminative schedule control over response rate in the absence of verbal descriptions. This difference in schedule control may account for the greater susceptability of response rate to verbal manipulation seen in past research as well as its decreased likelihood to conform to opposing contingencies when those contingencies are contacted. 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 a consequence of the more precise discriminative control by the schedules in the present research, verbal control was evidenced only under particular conditions. First, verbal control was not acheived when a history of control by a highly discriminative schedule preceeded the institution of a verbal rule. Second, transient verbal control was evidenced when the discriminative control of the schedules was decreased by use of nondifferential schedules (Experiment 2). Third, verbal control was inconsistently evidenced in the presence of opposing

schedules, and consistently evidenced in the presence of nondifferential schedules, following a history of correspondence between schedule and description. The past history of correspondence required to obtain even inconsistent verbal control under the opposing schedules is testimony to the discriminative control of the schedules employed in the present research. This history of correspondence may have served to increase the discriminative control of the rule, as well as decreasing the likelihood of contact with the opposing schedules. As mentioned previously, Hayes, Brownstein, Zettle, et al. (1986) divide rule-governed behavior into two classes: (a) behavior which follows a rule because of a past history of correspondence between the rule and natural contingencies (tracking), and (b) behavior which follows a rule because of a past history of social reinforcement for following rules (pliance). The history of correspondence between the verbal description and the schedule would allow the description to function as a track. The schedules themselves represent natural contingencies which may enhance the power of the verbal rule in discriminating response rate.

Alternatively, it might be argued that the maintenance of verbal control under opposing contingencies simply represents the persisting effects of prior schedule exposure. As discussed previously, this may have been the case when differential responding was maintained under nondifferential schedules. This theory seem less likely, however, when applied to phases in which opposing contingencies were encountered. As seen in Experiment 1, and in several cases in Experiment 3, contact

with opposing contingencies is likely to trap response rate after very few contacts with behavior. Consequently, in the present case, control from prior schedule exposure would be expected to weaken rapidly when new sets of contingencies are contacted.

The differences in verbal control between past and present research, although stemming primarily from differences in discriminative schedule control, may partially reflect the social contingencies on rule following evoked by the respective procedures. First, in the Catania et al. (1982) and Matthews et al. (1985) procedures, an experimenter is 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, undoubtedly brings a considerable social contingency into play. The experimenter may even be construed as possessing ongoing information regarding subject response rate, and therefore be immediately aware when subjects deviate from their response descriptions. The absence of the experimenter in the present procedure could weaken the social control of arbitrary rules once contingencies not in accord with those rules have been experienced. The social contingencies in the Hayes, Brownstein, Zettle, et al. (1986) manipulation are different, but perhaps no less compelling. The experimenter reads response-rate instructions out loud to the subject, who follows along on a printed sheet. Here again, although the experimenter was physically absent, the experimenter is conspicuous as the source of the instruction designating response rate.

The present procedure differs from each previously discussed in that (a) the experimenter is physically absent during sessions and (b) the instructions regarding response rate are presented by the computer. Both of these procedural differences would likely decrease the effect of social contingencies on rule-following behavior. Clearly, the way in which a rule is engendered may be of vital importance in estimating its impact on behavior. The effectiveness of a verbal description shaped by a computer in controlling response rate may be far less 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, one might question the role of the computer in maintaining rule-behavior correspondence. Explanatory references to social contingencies are presently speculative, however, since social contingencies were not manipulated in this research. The obvious test of the "social contingency" theory as an explanation of the disparity between the present results and those of past researchers, using the present procedures, would be to have the experimenter present and instrumental in awarding points for verbal descriptions during sessions. Such a manipulation might demonstrate greater verbal control than did the present procedure, with the experimenter uninvolved.

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 not having acheived such schedule control. This lack of precise schedule control is not surprising, of course, given the frequent difficulties encountered with obtaining precise schedule control in humans (e.g., Weiner, 1970). The present results do, however, demonstrate that this difficulty in obtaining precise schedule control may influence the relative strengths of schedule and verbal rule acting on response rate, thus determining whether verbal control is achieved.

The importance of these relative strengths could further be demonstrated by procedures designed to alter the strength of either or both influences on response rate. Using the present procedures, the discriminative control of the rule could be increased by specifying precise response rates (e.g., press at 3 responses/interval), as already mentioned, by having the experimenter present and instrumental in providing rules, and by lengthening the history of correspondence between description and rule. The discriminative control of the schedule could be decreased by varying the length of the interval prior to point presentation, or increased by retaining the constant interval but shortening its length. Perhaps the best way to increase discriminative control by the schedule would be to increase the point-award difference between the MaxPA response-rate range and less optimal rate ranges. Manipulation of these variables will help to demonstrate the conditional nature of verbal control of human nonverbal responding.

References

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

Baron, A., & Galizio, M. (1983). Instructional control of human operant behavior. Psychological Record, 33, 495-520.

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.

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' verbalization of the reinforcement contingency. Psychological Record, 18, 469-474.

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.

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.

Appendix A

Post-session Questionnaire

Post-Session Questionnaire

Please indicate your choice by placing a check or an "x" beside the appropriate response

1. Did you find the experimental task: ____interesting?

____mildly interesting?

____fairly boring?

____very boring?

2. How successful do you think you were in performing the experimental task early in the session? ____very successful?

____fairly successful?

____slightly successful?

____not successful at all?

3. How successful do you think you were in performing the experimental task late in the session? ____very successful?

____fairly successful?

____slightly successful?

____not successful at all?

4. In general, what strategy did you take in approaching the experimental task?

_____

_____

_____

_____

_____

Appendix B

Post-study Questionnaire

Post-Study Questionnaire

Please indicate your choice by placing a check or an "x" beside the appropriate response. For the study as a whole:

1. Did you find the experimental task: _____interesting?

_____mildly interesting?

_____fairly boring?

_____very boring?

2. How successful do you think you were in performing the experimental task? _____very successful?

_____fairly successful?

_____slightly successful?

_____not successful at all?

3. What, in general, do you think was the purpose of the study?

_____

_____

_____

_____

_____

4. In general, what strategy did you take in approaching the problem of determining the best pressing rate?

_____

_____

_____

_____

_____

5. In general, what strategy did you take in choosing the best description of pressing rate?

6. Did the rate at which you pressed the key relate to your choice on the question screen of which rate was best? If so, how?

7. Did your choice on the question screen of which rate was best relate to the rate at which you pressed the key? If so, how?

8. During the study, did you always press the key at the same rate as you chose on the question screen? If not, why not?

9. Did you find it was most important to earn points by:

___ pressing at the best rate

___ choosing the correct answer on the question screen

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10. When the rate for earning the most points on the key and the description that you chose on the question screen did not correspond, how did you resolve this dilemma?

11. Did you feel as though you were lying at any point in the study?

12. If so, what did you think was going on?

12. Was the money used as an incentive in this study sufficient to make the study worthwhile to you?

13. Can you think of anything that might serve to make the study more interesting and give more incentive to subjects if it was to be run again?