JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1992, 25, 143–151 NUMBER 1 (SPRING 1992)

THE EFFECTS OF VARIABLE-INTERVAL REINFORCEMENT ON ACADEMIC ENGAGEMENT: A DEMONSTRATION OF MATCHING THEORY

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The single-alternative form of the matching law has enjoyed extensive support in laboratory research with both animals and humans. However, few data exist concerning its validity as a description of behavior in applied settings. In Experiment 1, 2 fourth-grade students were exposed to variable-interval schedules of social reinforcement contingent on academic engagement. The data for each subject were then plotted via Herrnstein's equation. The results showed Herrnstein's equation to account for 99.1% and 87.6% of the variance in student engagement, respectively. In Experiment 2, control over student engagement by two of the reinforcement schedules was examined further within an alternating treatments design with similar results. The implications of these findings for linking experimental and applied behavior analysis are discussed.

DESCRIPTORS: matching theory, academic behavior, variable-interval reinforcement

Results from concurrent-schedule research have shown that, in a two-choice situation, the proportion of responding across alternatives matches the reinforcers derived from those same alternatives. This pattern has emerged as a consistent finding in over 30 years of concurrent-schedule research, giving rise to a mathematical statement of choice behavior termed the matching law (Herrnstein, 1961). The matching law has been obtained using a variety of response topographies and reinforcers, and has been found to hold for both response-rate and time-allocation data (Baum & Rachlin, 1969; Davison & McCarthy, 1988; McDowell, 1988, 1989).

In 1970, Herrnstein proposed a mathematically equivalent form of the matching law to describe situations in which reinforcement concurrently available to subjects was outside of experimenter control or was unspecified. Often referred to as a quantitative statement of the law of effect (de Villiers, 1977), the single-alternative form of the matching law is written as

$$R = \frac{kr}{r + r_e}$$

where R is the rate of the target response, k is the maximum possible rate of responding, r is the rate of reinforcement contingent upon the target response, and r_e is the rate of all other reinforcement delivered to the subject exclusive of the target response. According to Herrnstein's equation, with increases in contingent reinforcement the frequency or duration of behavior increases in the form of a hyperbola. The shape of this hyperbolic function is determined by the parameter r_e or extraneous reinforcement. When extraneous reinforcement is high, increases in contingent reinforcement produce relatively small increases in the occurrence of the target behavior, resulting in a nearly linear hyperbola. When extraneous reinforcement is low, increases in contingent reinforcement produce large increases in occurrence of the target behavior, resulting in an hyperbola nearly asymptotic over most of its range.

In recent years, there has been increased interest in attempts to apply matching theory as a description of naturally occurring human behavior (Martens & Witt, 1988; McDowell, 1982, 1988; Myerson & Hale, 1984; Pierce & Epling, 1980). The application of matching theory to naturally occurring human behavior is desirable for three reasons

The authors gratefully acknowledge the assistance of Kathleen Collins, Helen Jackson, Kelly Lawrence, Samia Markson, Amy Parks, Reginald Roberts, and Wendy Smith in collecting the data and the help of Jim Elkin and Kathy Turturo in calculating the reliability estimates.

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(McDowell, 1982; Pierce & Epling, 1980). First, analyzing behavior as choice is likely to produce more accurate predictions of response allocation than can be made using the law of effect (Pierce & Epling, 1980). Second, matching theory provides a unifying account of various processes that approximate choice behavior, such as behavioral contrast and responding under differential-reinforcement-of-other-behavior (DRO) schedules (Gross & Drabman, 1981; Parrish, Cataldo, Kolko, Neef, & Egel, 1986; Poling & Ryan, 1982). Third, the functional impact of concurrently available reinforcement suggests novel intervention strategies aimed at altering the *relative* rather than the absolute amount of reinforcement for responding (McDowell, 1982). For example, by increasing the relative attractiveness of desired responding, the generalization of treatment effects may be enhanced over time and across settings (Martens & Meller, 1990).

Despite the apparent value of matching theory as a description of human behavior, few data currently exist supporting its validity in applied settings. In a reanalysis of case study data, McDowell (1981a) fit Herrnstein's equation to rates of self-injurious scratching maintained by verbal reprimands in a 10-year-old boy. The resulting hyperbolic function relating scratches per hour to reprimands per hour accounted for over 99% of the variance in responding. More recently, Martens and Houk (1989) and Martens, Halperin, Rummel, and Kilpatrick (1990) showed Herrnstein's equation to account for an average of 54% of the variance in time-allocation measures of naturally occurring classroom behavior. In addition, the obtained hyperbolic functions varied in shape with teacher attention for competing behavior in the manner predicted by matching theory. Finally, Mace, McCurdy, and Quigley (1990) arranged concurrent schedules of reinforcement for successful completion of academic and vocational tasks. Although response requirements and reinforcers differed across the schedule components, rates of task completion approximated the relative amount of reinforcement programmed for each alternative.

The present study sought to extend previous research applying matching theory by arranging four variable-interval (VI) schedules of social reinforcement for academic engagement and then fitting Herrnstein's equation to the resulting data (Experiment 1). Although this procedure was similar to that reported in basic laboratory research (e.g., Catania, 1963; Findley, 1958; Herrnstein, 1961), the resulting ABCDE case study design yielded a weak demonstration of behavioral control. Therefore, the issue of control was addressed further in Experiment 2 by examining the behavior of 2 additional subjects under separate VI schedules within an alternating treatments design.

EXPERIMENT 1

Method

Subjects and Setting

Two male students, aged 10 years 6 months (Dan) and 9 years 6 months (Jim), who were in the same fourth-grade class participated in Experiment 1. Neither child had been referred previously for academic difficulties, and both were achieving in the average to above-average range as assessed by the Iowa Test of Basic Skills. Each subject had been identified by the classroom teacher as being off task during the majority of independent seatwork time and exhibiting frequent inappropriate behavior (e.g., talking without permission, being out of seat).

Sessions were conducted during 12- to 30-min periods each day in a fourth-grade elementary school classroom. During these times, students were required to work independently at their seats, completing assignments in social studies, science, or reading. The class was composed of 27 students, with a mean age of 9 years. The classroom was arranged in four rows of seven individual desks, all facing a large classroom-length blackboard. In addition to the teacher and students, a female experimenter and one or two observers were present in the classroom during the treatment sessions.

Target Behavior and Observational Procedures

Six categories of adult and peer behavior and seven categories of student behavior were recorded

Table 1
Behavior Categories and Definitions in Experiment 1

Adult and peer behavior	Student behavior
Teacher approval: Positive verbal comments evaluating subject behavior (praise) or positive physical contact (hand holding, patting).	Out of seat: Movement away from assigned seat or position when not explicitly granted by the teacher. The child's weight is not supported by the chair.
Teacher disapproval: Negative or critical statements evaluating subject behavior (reprimands) or negative or forcible physical contact (grabbing, spanking, shaking).	Noise: Production of audible noise other than by means of vocalization (e.g., finger or pencil tapping, banging together of books).
Individual instruction: Academic, procedural, or social comments by the teacher related to an academic task or classroom behavior directed to the subject (directions, feedback, assistance).	Vocalization: Any audible noise eminating from the mouth not including responses to teacher questions (e.g., humming).
Group instruction: Academic, procedural, or social comments by the teacher related to an academic task or classroom behavior directed to a group of which the subject is a member.	Touching: Coming into physical contact with another student, teacher, or their property directly or through the use of some object such as a pencil or ruler. This category included hitting, pushing, or tapping another student.
Peer approach: Interaction or attempts at interaction by a peer directed toward the subject that are verbal, physical, or involve facial expressions.	Playing: Silent manipulation of one's own property when such property is in no way connected with a learning activity or when property is part of a learning activity but is used in an inappropriate manner.
Experimenter approval: Positive verbal comments evaluating subject behavior (praise) delivered by the experimenter.	Inactivity: The child is not engaged in an assigned task and minimal overt behavior is demonstrated (staring into space).
	Engagement: The child is actively involved in completing an assigned task and is oriented toward work materials for an entire 10-s interval.

(Table 1). A 10-s partial-interval time sampling scheme was used to record the occurrence of all behavior categories except engagement. Engagement was recorded using a whole-interval procedure to obtain more conservative estimates of duration (Saudargas & Lentz, 1986).

Five graduate students served as observers and were trained for 8 weeks to 90% interrater reliability. Each observer listened to a cueing tape through an earphone and recorded at the tone any behavior categories that occurred during the 10-s interval. Each child was observed for 1 min before alternating to the other student. Observations were conducted during the same class periods each day and began immediately following teacher instruction. Because of variations in the teacher's instructional statements, observation sessions ranged from approximately 12 min to 30 min in length.

Reinforcement Procedure

The experimenter was equipped with a microcassette recorder and earphone, a 20-s fixed-time cueing tape, and a clipboard. The experimenter was instructed to listen to the cueing tape and to record at the tone subject engagement using a momentary time-sampling procedure. At certain intervals (predetermined by the VI schedule), the experimenter also delivered verbal praise to the subjects contingent on engagement. Praise consisted of some form of positive evaluation, together with a statement identifying the appropriate behavior (e.g., "I like the way you were working quietly on the assignment"). In the event that a subject was not academically engaged at the scheduled time for reinforcement, the subject remained eligible for reinforcement at the next interval signaled by the tone on the cueing tape.

Multiple versions of each of four VI reinforcement schedules were developed with mean intervals of 5, 4, 3, and 2 min. In the present experiment, 20 s was selected as the minimum interval between reinforcers. Random number sequences representing combinations of 20-s intervals were used to implement the VI schedules and were generated according to two criteria: (a) The mean number of intervals (and therefore mean duration) between reinforcers had to correspond to the desired schedule value (e.g., an average of six 20-s intervals for a

VI 2-min schedule), and (b) the total number of intervals had to sum to the desired length of an experimental session.

For each VI schedule, at least two session lengths were predetermined to maintain schedule integrity and to allow flexibility in accommodating variations in the class routine. Session lengths varied from multiples of 6 min for the VI 2-min schedule to multiples of 15 min for the VI 5-min schedule.

Procedure

Baseline. During baseline, the teacher was instructed to conduct class in the usual manner. Observers recorded all categories of teacher and student behavior (except the category experimenter approval).

VI reinforcement. During the treatment phases, the experimenter recorded the subject category of engagement using the momentary time-sampling procedure and provided reinforcement in the form of verbal praise at the scheduled intervals. Similar to the procedure used by Madsen, Becker, and Thomas (1968), praise was delivered by having the experimenter walk up to the subject, bend down, and comment on behavior in a soft voice. When not interacting with subjects or recording subject behavior, the experimenter moved about the classroom answering questions and providing assistance to nontarget peers. Following the initial baseline period, the richness of the VI schedule was increased in four phases (VI 5 min, VI 4 min, VI 3 min, VI 2 min), with the data for each phase serving as a contrast condition for each subsequent phase.

Results and Discussion

Estimates of interobserver agreement were obtained intermittently during 37% of the observation sessions for each category of student and adult/peer behavior, using 10-s intervals as the units of analysis. Reliability was calculated from the records of two independent observers by taking the number of agreements divided by the number of agreements plus disagreements and multiplying by 100. Percentage agreement ranged from an average of 88.9% for inactivity to 100% for touching, with a mean of 95.1% across the coding categories.

The left-hand portion of Figure 1 depicts the percentage of intervals in which engagement was observed for each subject across all phases of the experiment. Data were collected during 22 sessions for Dan and 21 sessions for Jim. The data for Dan showed considerable variability during baseline, with rates of engagement ranging from a low of 8% to a high of 90% (M = 45%). After the introduction of treatment using a VI 5-min schedule, engagement rates were more stable with a mean of 33.7%. Increasing the rate of reinforcement to a VI 4-min schedule was accompanied by sharp increases in engagement rates during the beginning of the phase and a declining trend over the final two sessions. The mean rate of engagement under the VI 4-min schedule was 65.2%. Under the VI 3-min and VI 2-min schedules, engagement rates were high, with means of 86.5% and 93.7%, respectively.

For Jim, engagement rates were also variable at baseline, ranging from a low of 8% to a high of 47% (M = 28.7%). Engagement rates showed a slight increase over the final two sessions of baseline to a mean of 17.5% with introduction of the VI 5-min schedule. Under the VI 4-min schedule, rates of engagement increased to a mean of 58.8%, showing marked variability across sessions. Under the VI 3-min schedule, the mean engagement rate decreased slightly (M = 55.0%), but increased markedly with the shift to a VI 2-min schedule (M = 79.5%). Decreasing trends were evident in each of the latter two conditions.

Although variability in engagement rates was observed during baseline and decreasing trends occurred in all but one condition (VI 5 for Jim, in which engagement rates were already quite low), increments in the reinforcement schedule were accompanied initially by increases in engagement for both subjects. Comparing the mean percentage of engagement under the VI 5-min and the VI 2-min schedule revealed increases of 60% for Dan and 62% for Jim. The increases in mean engagement rates, together with decreases in variability during the final phases of treatment, suggested that student behavior was responsive to the reinforcement procedures.

Herrnstein's equation was fitted to the data obtained for each subject using Wilkinson's method

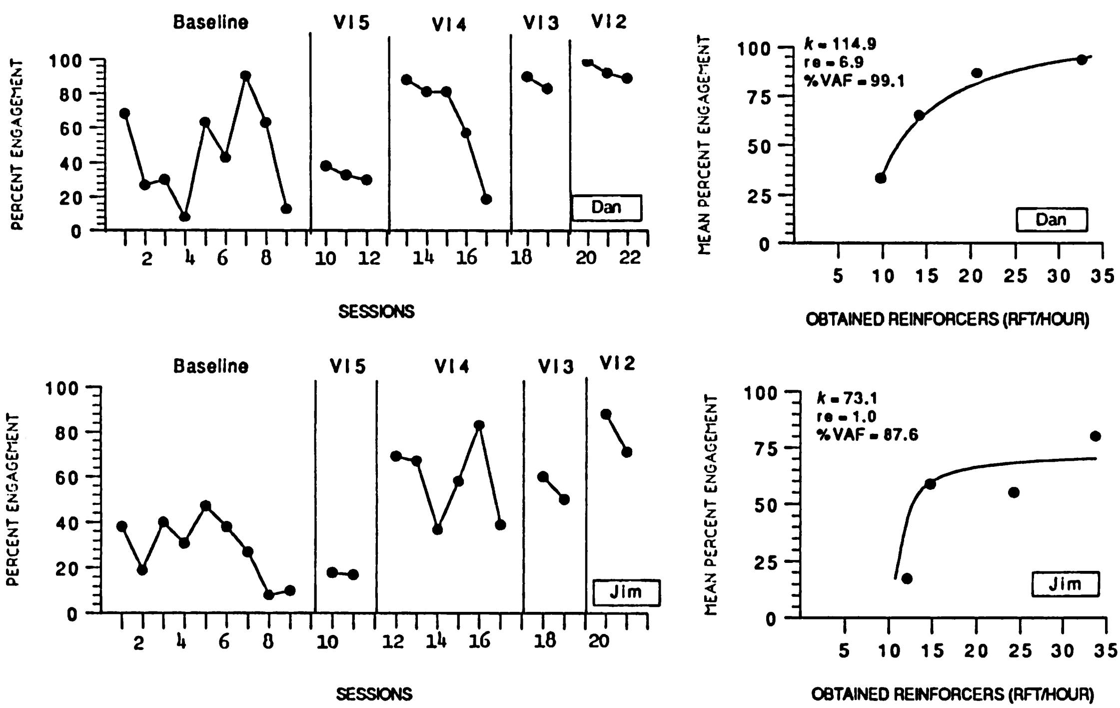

Figure 1. Percentages of academic engagement for each child across all conditions in Experiment 1 (left side). Mean percentages of academic engagement plotted against mean numbers of obtained reinforcers (expressed in reinforcers per hour) for each treatment condition, the fitted hyperbolic functions, and the estimated equation parameters (right side).

(Davison & McCarthy, 1988; Martens et al., 1990; McDowell, 1981b). In addition to calculating the parameter estimates and their standard errors, Wilkinson's method also provides the percentage of variance accounted for (%VAF) by the fitted hyperbolic functions.

Because matching theory is a quantitative description of steady-state responding, Herrnstein's equation is typically applied to data that have been summed or averaged at each schedule value (e.g., Bradshaw, Szabadi, & Bevan, 1976; Davison, 1988). In the present study, this was accomplished by computing the mean percentage of academic engagement across all days in which each of the four VI schedules was in effect. These data were then plotted against the mean frequency of obtained reinforcers at each schedule value (expressed in reinforcers per hour), resulting in four data points per subject.

Shown in the right-hand portion of Figure 1 are the plots of academic engagement by obtained reinforcement for each child, the fitted hyperbolic functions, and the estimated equation parameters. It should be noted that the data for each child were adjusted downward in their respective axes in order to locate the first data point at the origin (i.e., data obtained under the VI 5-min schedule) prior to fitting the hyperbolic functions. This was done for two reasons. First, programmed reinforcement in the form of experimenter praise was provided above and beyond uncontrolled reinforcement from other sources (e.g., teacher attention). As a result, it was impossible to determine the ***absolute*** amount of reinforcement contingent on academic engagement. Any attempt to position the data sets along the abscissa would therefore have been arbitrary. Second, because Herrnstein's equation is constrained to pass through the origin, arbitrarily positioning the data sets along the abscissa would have distorted the fitted hyperbolic functions and biased downward the estimates of variance accounted for.

As indicated in Figure 1, the single-alternative form of the matching law accounted for 99.1% and 87.6% of the variance in academic engagement. A smooth hyperbolic function that reached its asymptote, *k,* at a value of 114.9 was obtained for Dan. The estimated value of r_e for Dan was 6.9 reinforcers per hour. The pattern of responding for Jim resulted in a lower estimated value of r_e (1.0 reinforcers per hour), producing a hyperbolic function that approached its asymptote of 73.1 more rapidly.

Independent estimates of extraneous reinforcement were also obtained for each child by computing the percentage of intervals in which observers scored individual attention from the teacher or a peer together with the occurrence of inappropriate behavior. Consistent with the parameters obtained from fitting Herrnstein's equation, the average amount of extraneous reinforcement estimated from the observational data was higher for Dan (27.6%) than for Jim (15.6%).

The procedures used in Experiment 1 were designed to replicate two features of basic laboratory research. First, subjects were exposed to four VI schedules of reinforcement arranged in order of increasing richness (i.e., number of reinforcers per hour). Second, the data within conditions were averaged prior to fitting Herrnstein's equation. Despite these similarities, Experiment 1 contained several limitations, including (a) the small number of sessions per condition, (b) variability and downward trends in the data within conditions, and (c) the absence of an experimental design. Taken together, these limitations call into question whether control over student engagement was established by the reinforcement procedures. These concerns were partially addressed in Experiment 2 by exposing 2 additional subjects to the VI 5-min and VI 2-min reinforcement schedules within an alternating treatments design (Barlow & Hayes, 1979) and conducting multiple sessions per condition.

EXPERIMENT 2

Method

Subjects, Setting, and Observational Procedures

Two 8-year-old male students who were in the same third-grade class served as subjects in Experiment 2. As in Experiment 1, the subjects were identified by their classroom teacher as students whose off-task behavior was serious enough to warrant intervention (i.e., resulted in frequent failure to complete assignments and was disruptive to others).

Sessions were conducted during the same 30-min period each morning in the subjects' third-grade classroom. The class was composed of 22 students, with a mean age of 8 years. The classroom was arranged in five rows of desks, with a table for small-group reading instruction located at the left rear of the room. In addition to the teacher and students, a female experimenter and one or two observers were present in the classroom throughout the alternating treatments conditions.

Engagement (as defined in Experiment 1) was the only category of student behavior recorded in Experiment 2. Except for this change in the number of categories coded, the observational procedures were identical to those reported in Experiment 1.

Reinforcement Procedure

One female experimenter delivered praise according to a VI 5-min or VI 2-min reinforcement schedule in the same fashion as described in Experiment 1. To facilitate discrimination between the two conditions, the experimenter held a red clipboard with "batman" stickers and stood on the right side of the classroom between student contacts for the VI 5-min condition. For the VI 2-min condition, the experimenter held a green clipboard with "race car" stickers and stood on the left side of the classroom between student contacts.

Procedures and Design

Baseline. During baseline, the teacher was instructed to conduct class in the usual manner. Observers recorded student engagement during independent seatwork.

Alternating treatments conditions. During alternating treatments conditions, the experimenter recorded engagement and provided reinforcement in the form of verbal praise at the scheduled intervals. Praise was delivered according to either the VI 5-min or VI 2-min reinforcement schedule each day, with the order of conditions alternated in a

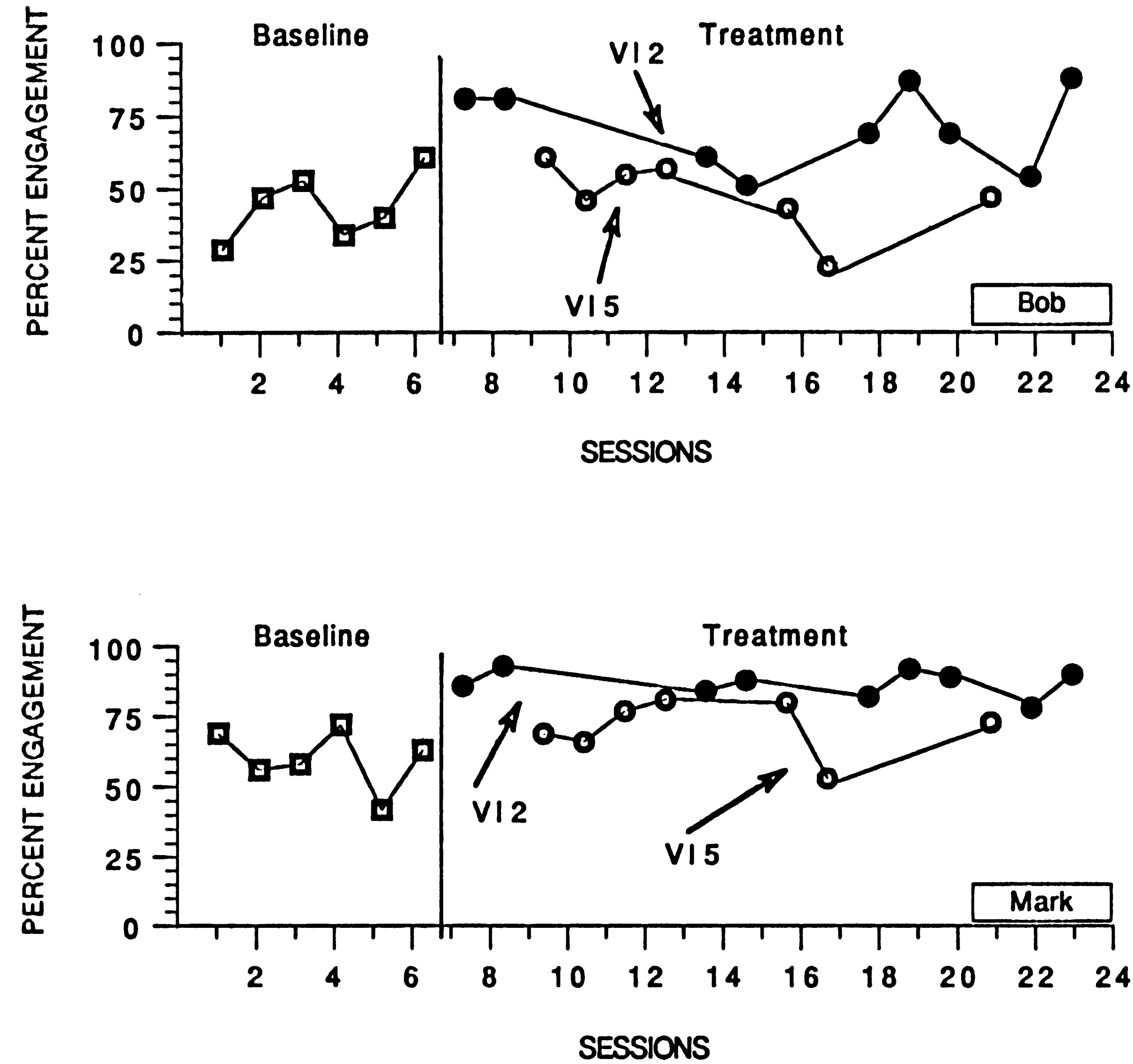

Figure 2. Percentages of academic engagement for each child during baseline and the alternating treatments conditions in Experiment 2.

semirandom fashion. Only one reinforcement schedule was implemented per day.

Results and Discussion

Estimates of interobserver agreement were obtained during 45% of the sessions throughout the experiment. Reliability was calculated from the records of two independent observers by taking the number of agreements divided by the number of agreements plus disagreements and multiplying by 100. Mean interobserver agreement was 96% (range, 93% to 98%).

Percentages of engagement for each child across all phases of the experiment are presented in Figure 2. During baseline, the mean percentage of engagement for Bob was 44.0%. Under the VI 2-min schedule, engagement rates increased to a mean of 71.3%. Under the VI 5-min schedule, engagement rates were consistently lower and more variable compared to the VI 2-min schedule, with a mean of 47.4%.

The mean percentage of engagement for Mark during baseline was 60.0%. Under the VI 2-min schedule, engagement rates were consistently high and stable, with a mean of 86.9%. Similar to the data for Bob, engagement rates under the VI 5-min schedule were consistently lower and more variable in comparison to the VI 2-min schedule, with a mean of 71.3%. Data obtained under the two alternating treatments conditions were clearly discriminable for both subjects, suggesting that control over behavior had been established by the reinforcement procedures (Hayes, 1981).

GENERAL DISCUSSION

The growing distinction between experimental and applied behavior analysis has resulted in a paucity of research extending basic science principles to naturally occurring human behavior (e.g., Mace et al., 1988; Martens et al., 1990). Particularly overlooked in applied research have been mathematical accounts of behavior, such as matching theory, which enjoy extensive support in the laboratory (McDowell, 1988). In Experiment 1, we arranged VI schedules of social reinforcement contingent on academic engagement and fit the resulting data to Herrnstein's equation. The results showed Herrnstein's equation to account for 99% and 88% of the variance in engagement for the 2 subjects, respectively. In Experiment 2, we used an alternating treatments design to provide further evidence that subject behavior was under control of the reinforcement procedures.

The present research represents one of few attempts to apply matching theory as a description of naturally occurring human behavior (e.g., Martens & Houk, 1989; McDowell, 1981a). Moreover, this research marks the first attempt to evaluate the single-alternative form of the matching law in a natural setting by experimentally arranging social reinforcement. Although each experiment employed VI reinforcement contingent on student engagement, reinforcement for alternative responding (i.e., inappropriate behavior) was uncontrolled. Future research in which both components of a concurrent schedule are controlled by the experimenter would extend the present findings and enable more precise examinations of choice. Future research in which concurrent VR schedules of reinforcement are examined is also needed. Mace et al. (1990) have reported a procedure that may be useful in this type of research. Moreover, the system developed in the present study to implement VI schedules can also be used to implement variable-ratio schedules by noting the presence or absence of behavior at each interval and using these data to prescribe reinforcement delivery.

The present results argue in favor of extending principles derived from basic research to naturally occurring human behavior. Several authors have noted that advances in the experimental analysis of behavior have gone largely unrecognized by applied behavior analysts (e.g., Pierce & Epling, 1980). As an operant theory of choice behavior, matching theory may prove successful in explaining complex behavior–environment relationships where other approaches have not (McDowell, 1982; Parrish et al., 1986). We hope the present findings will stimulate future research on this topic, and in so doing strengthen the relationship between experimental and applied behavior analysis.

REFERENCES

Barlow, D. H., & Hayes, S. C. (1979). Alternating treatments design: One strategy for comparing the effects of two treatments in a single subject. *Journal of Applied Behavior Analysis,* **12,** 199–210.

Baum, W. M., & Rachlin, H. C. (1969). Choice as time allocation. *Journal of the Experimental Analysis of Behavior,* **12,** 861–874.

Bradshaw, C. M., Szabadi, E., & Bevan, P. (1976). Behavior of humans in variable-interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior,* **26,** 135–141.

Catania, A. C. (1963). Concurrent performances: Reinforcement interaction and response independence. *Journal of the Experimental Analysis of Behavior,* **6,** 253–263.

Davison, M. (1988). Concurrent schedules: Interaction of reinforcer frequency and reinforcer duration. *Journal of the Experimental Analysis of Behavior,* **49,** 339–349.

Davison, M., & McCarthy, D. C. (1988). *The matching law: A research review.* Hillsdale, NJ: Erlbaum.

de Villiers, P. (1977). Choice in concurrent schedules and a quantitive formulation of the law of effect. In W. K. Honig & J. E. R. Staddon (Eds.), *Handbook of operant behavior* (pp. 233–287). Englewood Cliffs, NJ: Prentice-Hall.

Findley, J. D. (1958). Preference and switching under

concurrent scheduling. *Journal of the Experimental Analysis of Behavior,* **1,** 123–144.
Gross, A. M., & Drabman, R. S. (1981). Behavioral contrast and behavior therapy. *Behavior Therapy,* **12,** 231–246.
Hayes, S. C. (1981). Single case experimental design and empirical clinical practice. *Journal of Consulting and Clinical Psychology,* **49,** 193–211.
Herrnstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of the Experimental Analysis of Behavior,* **4,** 267–272.
Herrnstein, R. J. (1970). On the law of effect. *Journal of the Experimental Analysis of Behavior,* **13,** 243–266.
Mace, F. C., Hock, M. L., Lalli, J. S., West, B. J., Belfiore, P., Pinter, E., & Brown, D. K. (1988). Behavioral momentum in the treatment of noncompliance. *Journal of Applied Behavior Analysis,* **21,** 123–141.
Mace, F. C., McCurdy, B., & Quigley, E. A. (1990). A collateral effect of reward predicted by matching theory. *Journal of Applied Behavior Analysis,* **23,** 197–205.
Madsen, C. H., Becker, W. C., & Thomas, D. R. (1968). Rules, praise, and ignoring: Elements of elementary classroom control. *Journal of Applied Behavior Analysis,* **1,** 139–150.
Martens, B. K., Halperin, S., Rummel, J. E., & Kilpatrick, D. (1990). Matching theory applied to contingent teacher attention. *Behavioral Assessment,* **12,** 139–156.
Martens, B. K., & Houk, J. L. (1989). The application of Herrnstein's law of effect to disruptive and on-task behavior of a retarded adolescent girl. *Journal of the Experimental Analysis of Behavior,* **51,** 17–27.
Martens, B. K., & Meller, P. J. (1990). The application of behavioral principles to educational settings. In T. B. Gutkin & C. R. Reynolds (Eds.), *The handbook of school psychology* (2nd ed., pp. 612–634). New York: Wiley.
Martens, B. K., & Witt, J. C. (1988). Ecological behavior analysis. In M. Hersen, R. M. Eisler, & P. M. Miller (Eds.), *Progress in behavior modification* (Vol. XXII, pp. 115–140). Beverly Hills, CA: Sage.
McDowell, J. J. (1981a). On the validity and utility of Herrnstein's hyperbola in applied behavior analysis. In C. M. Bradshaw, E. Szabadi, & C. F. Lowe (Eds.), *Quantification of steady-state operant behaviour* (pp. 311–324). Amsterdam: Elsevier/North-Holland.
McDowell, J. J. (1981b). Technical note: Wilkinson's method of estimating the parameters of Herrnstein's hyperbola. *Journal of the Experimental Analysis of Behavior,* **35,** 413–414.
McDowell, J. J. (1982). The importance of Herrnstein's mathematical statement of the law of effect for behavior therapy. *American Psychologist,* **37,** 771–779.
McDowell, J. J. (1988). Matching theory in natural human environments. *The Behavior Analyst,* **11,** 95–109.
McDowell, J. J. (1989). Two modern developments in matching theory. *The Behavior Analyst,* **12,** 153–166.
Myerson, J., & Hale, S. (1984). Practical implications of the matching law. *Journal of Applied Behavior Analysis,* **17,** 367–380.
Parrish, J. M., Cataldo, M. F., Kolko, D. J., Neef, N. A., & Egel, A. L. (1986). Experimental analysis of response covariation among compliant and inappropriate behaviors. *Journal of Applied Behavior Analysis,* **19,** 241–254.
Pierce, W. D., & Epling, W. F. (1980). What happened to analysis in applied behavior analysis? *The Behavior Analyst,* **3,** 1–9.
Poling, A., & Ryan, C. (1982). Differential-reinforcement-of-other behavior schedules. *Behavior Modification,* **6,** 3–21.
Saudargas, R. A., & Lentz, F. E. (1986). Estimating percent of time and rate via direct observation: A suggested observational procedure and format. *School Psychology Review,* **15,** 36–48.

Received June 27, 1990
Initial editorial decision September 4, 1990
Revisions received December 31, 1990; April 3, 1991
Final acceptance June 12, 1991
Action Editor, David P. Wacker