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POSITIVE AND NEGATIVE REINFORCEMENT EFFECTS ON BEHAVIOR

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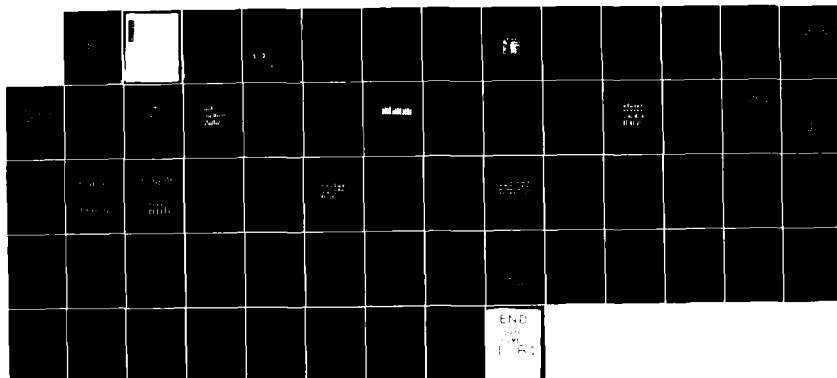
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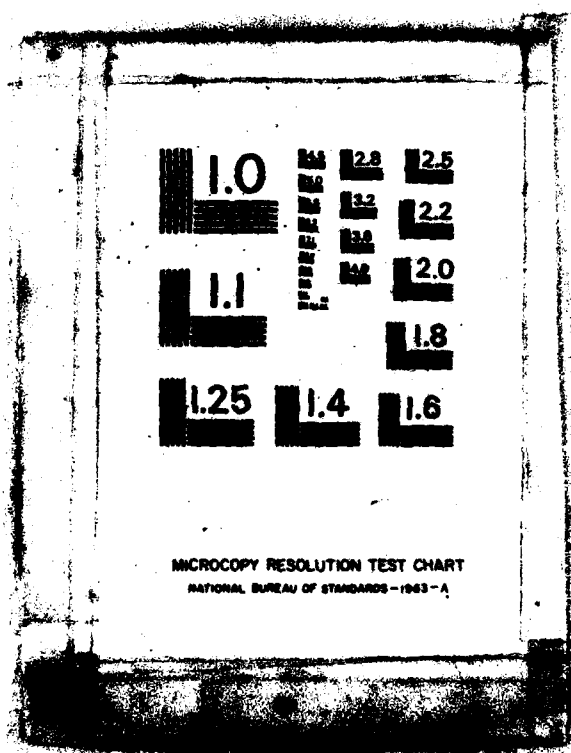
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TR-ONR-9	2. GOVT ACCESSION NO. AD-A125262	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Positive and negative reinforcement effects on behavior in a three-person microsociey		5. TYPE OF REPORT & PERIOD COVERED Technical Report
7. AUTHOR(s) Henry H. Emurian, Joseph V. Brady, James L. Meyerhoff, and Edward H. Mougey		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Psychiatry The Johns Hopkins University School of Medicine		8. CONTRACT OR GRANT NUMBER(s) N00014-80-C-0467
11. CONTROLLING OFFICE NAME AND ADDRESS Organizational Effectiveness Research Programs Office of Naval Research (Code 452) Arlington, VA 22217		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS NR 170-910
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		12. REPORT DATE 1 December 1983
		13. NUMBER OF PAGES 50
		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		16a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report)  Approved for public release, distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES / This research was also supported by NASA Grant NGR 21-001-111. - <u>Journal of the Experimental Analysis of Behavior</u> , submitted.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)  Programmed environment, microsociey, aggression, aversive control.		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  ✓ Three-person groups of males (G1, G2, and G4) and females (G3) resided for 6 to 12 days in a continuously programmed environment. Subjects followed a behavioral program that determined the sequential and contingent relationships within an inventory of activities. During a		

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positive reinforcement day, each "work unit" completed by a subject incremented a group account that was divided evenly among the 3 participants at the study's conclusion. During a negative reinforcement day, no money was earned, and the group was assigned a "work unit" criterion to accomplish to avoid a reduction in accumulated earnings. During avoidance days, subjects exhibited aggressive responses, which differed in magnitude among the 4 groups, as determined from several distinct behavioral measures that reflected the overall status of the micro-society. These effects appear to fall within the conceptual and procedural framework that encompasses analyses of by-products of aversive control, and they suggest that similar variables are operative.

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**POSITIVE AND NEGATIVE REINFORCEMENT EFFECTS  
ON BEHAVIOR IN A THREE-PERSON MICROSOCIETY**

Previous studies indicated the practicality of within-group investigations of variables that affect the status of a three-person microsociey, and they demonstrated the effectiveness of a programmed environment methodology in undertaking such studies (Emurian, Bigelow, Brady, and Emurian, 1976; Emurian, Emurian, and Brady, 1978). It was learned, for example, that cooperation contingencies embedded within a behavioral program had the effect of increasing the durations of triadic social episodes. By-products of the cooperation contingency included increased intercom communications among subjects, increased intersubject program synchronization, and the prevention of social isolation or withdrawal that was sometimes associated with degradation in individual performance on an arithmetic calculations task (Emurian and Brady, in press). It was the case, however, that adverse effects were never so intense as to warrant unplanned reversals in experimental conditions or other interventions to restore a failing microsociey to effective functioning. In fact, social fragmentation and subject pairing effects were the primary indicators of change in the status of a group.

To further the behavior analysis of confined microsocieties under programmed environment conditions, the range of variables considered for investigation was broadened to include negative reinforcement procedures. It was assumed that the comprehensive programming and measurement capabilities developed in previous work might prove equally effective in

detecting by-products of aversive control and, more importantly, might show by comparison the merits of alternative positive reinforcement procedures in maintaining behavior. The present fact-finding series of studies was also influenced by evidence linking (1) hostility and aggression with aversive control (e.g., Hutchinson, 1976) and (2) dissipation of hostility to cooperative goals pursued under conditions of positive reinforcement (e.g., Deutsch, 1963; Sherif, 1967). The purpose of the research, then, was to develop a laboratory model for the identification and analysis of conditions that may provoke undesirable responses by inhabitants of a confined micro-society.

#### METHOD

##### Subjects

In response to recruitment notices placed in a local newspaper, four 3-person groups consisting of nine males (G1, G2, and G4) and three females (G3) were accepted for participation on the basis of psychological evaluation, educational background, and availability. The mean age of a subject was 24.0 years with a range between 18 and 34 years. No subject showed problematical issues or disruptive dispositions as evidenced by the results of the Minnesota Multiphasic Personality Inventory and the 16 Personality Factors Inventory, respectively. Subjects were fully informed about procedures, and they were familiarized with the laboratory as a group during orientation and training sessions that preceded an experiment. There were no elements of deception involved in the research, and informed consent was obtained. Remuneration was a function of work-task

productivity under conditions described below.

### Apparatus

The programmed environment consisted of five rooms and an interconnecting corridor. The floor plan of the laboratory and its position within the surrounding building shell are presented in Emurian, Bigelow, Brady, and Emurian (1976). Each of three private rooms (2.6 x 3.4 x 2.4 m) was similar to a small efficiency apartment containing kitchen, bathroom, bed, desk, and a computer CRT terminal. The recreation area (4.3 x 6.7 x 2.7 m) contained a complete kitchen facility along with exercise equipment and games. The workshop (2.6 x 4.1 x 2.7 m) contained assembly projects for Groups 1-3 and a computer CRT terminal for Group 4. A common bathroom served the recreation and workshop areas. Descriptions of the laboratory have been published elsewhere (Bigelow, Emurian, and Brady, 1975; Brady, Bigelow, Emurian, and Williams, 1975; Emurian, Ray, Brady, Meyerhoff, and Mougey, 1983).

### Behavioral Program

Figure 1 presents a diagrammatic representation of the behavioral program that determined the sequential and contingent relationships within the inventory of activities. For G4, Physical Exercise (PE) was located between Autogenic Behavior (AB) and Food One (FD1). Details regarding the composition of the behavioral program and the methods for stimulus control of component activities have been described previously (Emurian, Bigelow, Brady, and Emurian, 1976; Emurian, Emurian, and Brady, 1978; Emurian,



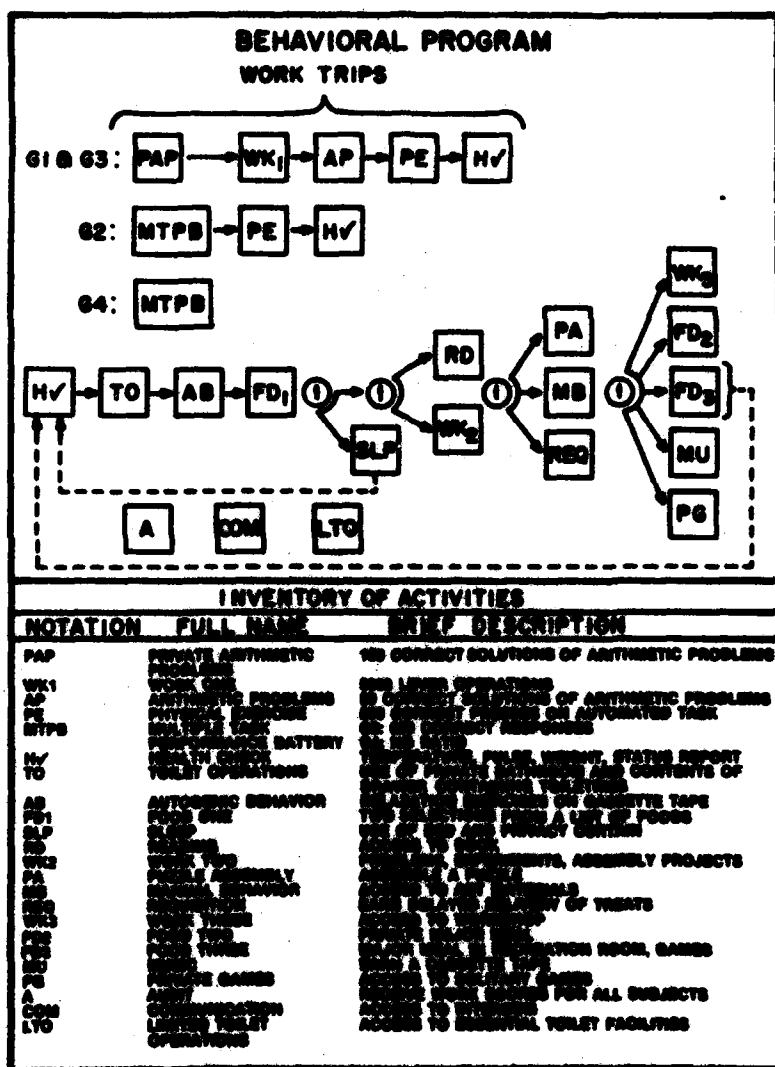


Figure 1. A diagrammatic representation of the behavioral program that determined the sequential and contingent relationships within the inventory of activities. For G4, Physical Exercise (PE) was located between Autogenic Behavior (AB) and Food One (FD1).

Emurian, Schmier, and Brady, 1979). For the present experiment, the critical feature of the program was the work trip. A work trip was available for selection between any two adjacent activities within the full behavioral program. Once a work trip had been selected, the subject completed all performance requirements before resuming the behavioral program from the point of departure. During a work trip, the intercom (COM) was not available, and the subject was not permitted access to music, thereby preserving these reinforcers for other occasions.

The Multiple Task Performance Battery (MTPB) was composed of the following five tasks that were displayed simultaneously to an operator via a CRT terminal: (1) blinking lights, a dynamic signal detection task, (2) warning lights, a static signal detection task, (3) probability monitoring, an integrated signal detection task, (4) target identification, a matching task, and (5) arithmetic calculations, a computational task. Accurate responses produced points that were presented on the screen as they were accumulated. The parameters of the tasks were chosen so that an operator with 5-10 hours of practice could accumulate 500-600 points per hour, and the upper limit of performance was approximately 750 points per hour. A description of this minicomputer-controlled performance battery has been published by Emurian (1978), and a rationale for this "synthetic work" methodology has been presented by Morgan and Alluisi (1972). Group 1 and G3 were presented with the arithmetic calculations component of the battery (i.e., PAP and AP), and G2 and G4 were presented with the full battery (i.e., MTPB).

For Groups 1-3, work trips were completed within the private rooms, and subjects could select them concurrently. For G4, a single CRT terminal was located within the workshop that subjects could occupy one-at-a-time on a self-determined rotational basis. For Groups 1-3, the parameters of the components of a work trip were chosen such that 1 to 2 hours were required to complete each trip. For G4, the parameters of the MTPB were chosen such that approximately 600 points per hour could be earned. Per-hour earning potential was roughly equivalent among the groups.

#### Procedure

The consequences of completing a work trip were varied to assess the effects of positive and negative performance-consequence relationships on the status of the microsociey. Under a positive reinforcement schedule (Appetitive Condition A), each work trip completed by an individual subject within Groups 1-3 produced a \$10 increment in a group account that was divided evenly among the three subjects at the conclusion of the experiment. For G4, each MTPB performance point produced a 1-cent increment to the group account. Under a negative reinforcement schedule (Avoidance Condition B), completion of work trips did not produce increments in a group account. Under Condition B, each group was assigned a criterion (trips for Groups 1-3, points for G4) to accomplish during a 24-hour period. Uncompleted trips (or points) below the criterion produced a decrement in the group account identical in magnitude to the increments produced during Condition A. Subjects were fully apprised of the two reinforcement schedules, but they were not told the order and duration.

In summary, then, for Groups 1-3, the completion of each work trip was maintained by a fixed-ratio contingency during an appetitive day, and during an avoidance day, the ratio size was increased to the prevailing criterion. For G4, MTPB performance was maintained by a continuous reinforcement contingency during appetitive days and by a fixed-ratio contingency during avoidance days.

For Groups 1-4, Conditions A and B were investigated in the following order and number of successive days under each condition, respectively: G1: A-B-A (4,4,2), G2: A-B-A-B (3,3,3,3), G3: A-B-A (3,6,3), and G4: A-B-A (2,3,1). At the beginning of each 24-hour day, subjects were notified, by a message on a communication CRT within each private room, about the condition that would be in effect for that day. On avoidance days, the trip or point criterion was repeated at the beginning of each consecutive avoidance day. Only one multiple reversal was conducted (i.e., G2) because of the untoward effects, described below, of ending an experiment with an avoidance condition. The trip criterion during avoidance days was based upon group productivity observed during immediately preceding appetitive days. For Groups 1-4, the daily avoidance criteria were as follows: G1, 20 trips; G2, 13 trips and 15 trips for the two respective avoidance conditions; G3, 15 trips; and G4, 12700 MTPB points.

#### RESULTS

**Relationship Between Avoidance and Appetitive Days.** A direct relationship is evident between the number of trips completed on a given day and the number of trips completed on the following day.

schedules. During each Health Check activity, each subject rated the Behavioral Program Condition (A or B) on a 4-point scale where 1 = not bothered by the program and 4 = extremely bothered by the program. These scale anchors also apply to rating data presented below. Figure 2 presents mean ratings of the behavioral program for all subjects in each group across successive days of the experiment. For all subjects, the highest rating occurred during avoidance days, and the reversability of this effect was indicated by comparatively low ratings that occurred during appetitive days that followed avoidance days. Nine of the 12 subjects showed a gradual increase in ratings across successive avoidance days. In contrast, S1 and S3 in G3, composed of females, showed a decrease in ratings across successive avoidance days after initially elevated ratings on the first few days following introduction of the avoidance condition. Finally, with the exception of S1 on Day 4, subjects within G3 did not rate the behavioral program as bothersome during avoidance days as did subjects within remaining groups, despite 6 successive days within the avoidance condition.

Ratings of the Experimenters. A subject's verbal behavior in relationship to the experimenters sometimes changed as a function of the two reinforcement schedules. Figure 3 presents mean ratings of the experimenters for all subjects in each group across successive days of the experiment. Eight of the 12 subjects expressed greatest annoyance with the experimenters during the avoidance condition, and the overall differences between the conditions were significant ( $t=2.80$ ,  $p<.02$ ,  $df=11$ ). Two subjects showed greatest annoyance during the appetitive condition (S1, G3

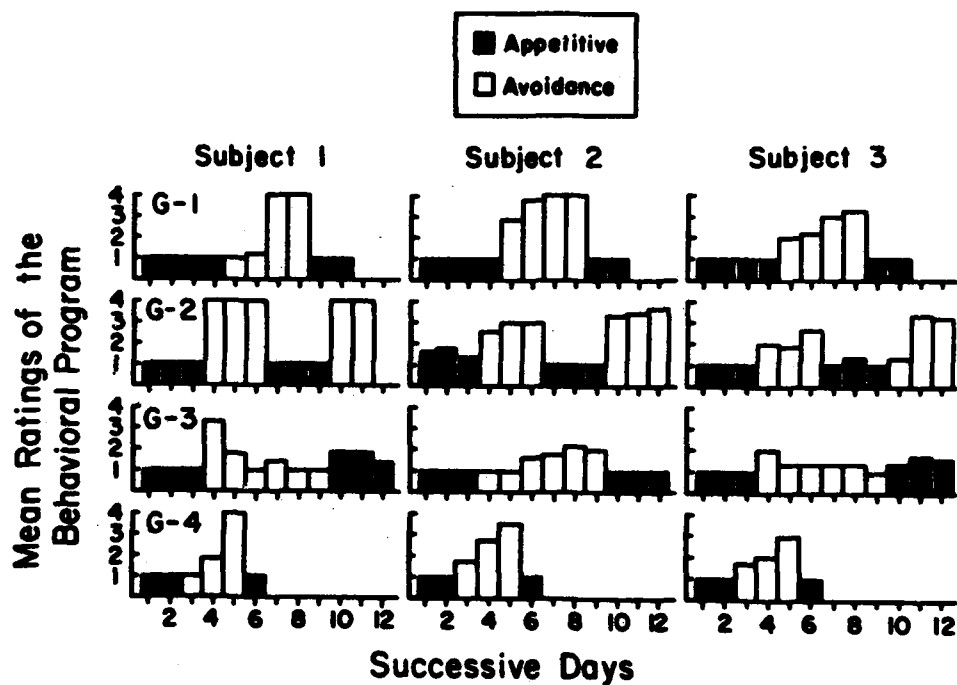


Figure 2. Mean ratings of the behavioral program for all subjects in each group across successive days of the experiment. 1 = not at all bothered by the program, and 4 = extremely bothered.

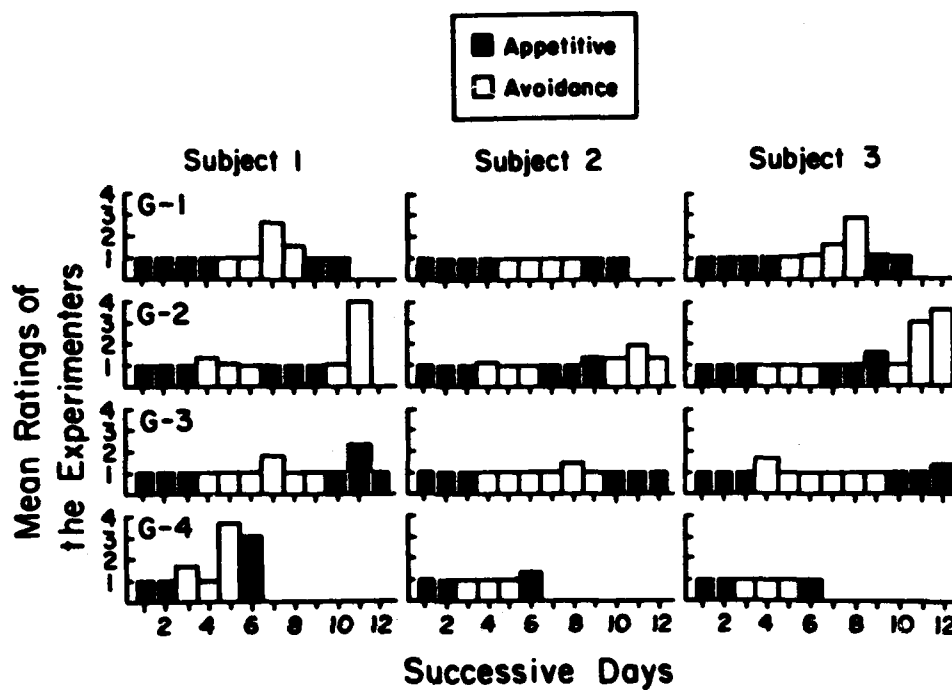


Figure 3. Mean ratings of the experimenters for all subjects in each group across successive days of the experiment. 1 = not at all bothered by the experimenters, and 4 = extremely bothered.

and S2, G4), and two subjects never expressed annoyance (S2, G1; S3, G4). Finally, the greatest degree of annoyance was expressed during the avoidance condition (e.g., S1, G2, Day 11; S1, G4, Day 5).

Interpersonal Ratings. A subject's verbal behavior in relationship to other subjects within a group sometimes changed as a function of the two reinforcement schedules. Figure 4 presents mean interpersonal ratings for all subject pairs in each group across successive days of the experiment. Subject 2 and S3 within G1 and all subjects within G4 expressed greater annoyance with other subjects during avoidance days than during appetitive days. Subjects within G2 showed infrequent expressions of annoyance, and subjects within G3, composed of females, showed no departure from "1" across 12 successive days.

Social Time. Figure 5 presents social activity durations, both dyadic and triadic, for all groups across successive days of the experiment. The order of the social episode within a day is indicated by successive ordinal positions above the abscissa. Group 2 and G3, the 12-day groups, showed triadic episodes on 10 and 9 experimental days, respectively. (Two separate triadic episodes were exhibited by G1 on Day 2.) In contrast, S2 in G1 failed to participate in social episodes from Days 7-10, after participating in 6 successive daily triadic episodes. Subjects in G4 never exhibited a triadic episode, and only 2 dyadic episodes occurred during that 6-day experiment. These latter dyadic episodes never involved S1 and S3 together.

Trip Performance. Figure 6 presents cumulative records of 4 work



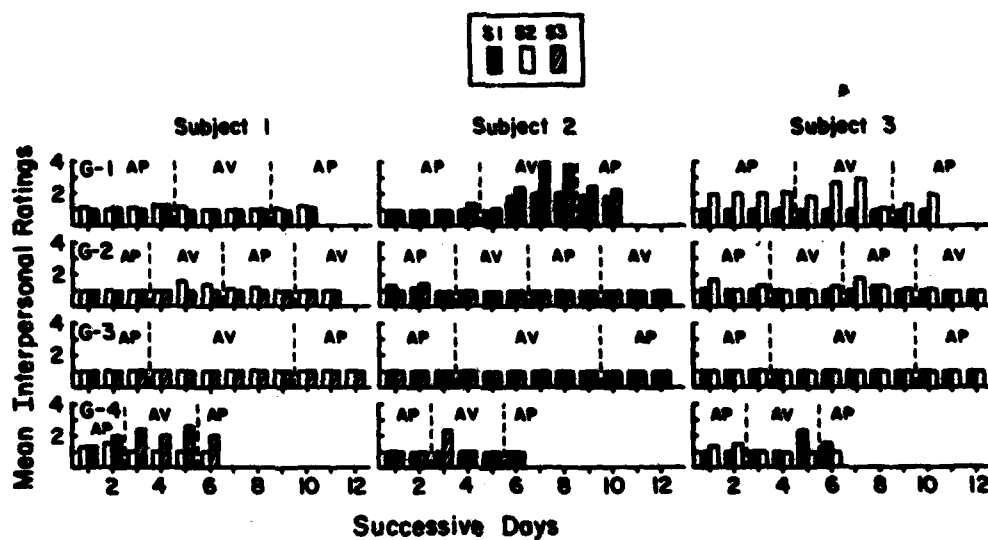


Figure 4. Mean interpersonal ratings for all subject pairs in each group across successive days of the experiment. 1 = not at all bothered by a subject, and 4 = extremely bothered.

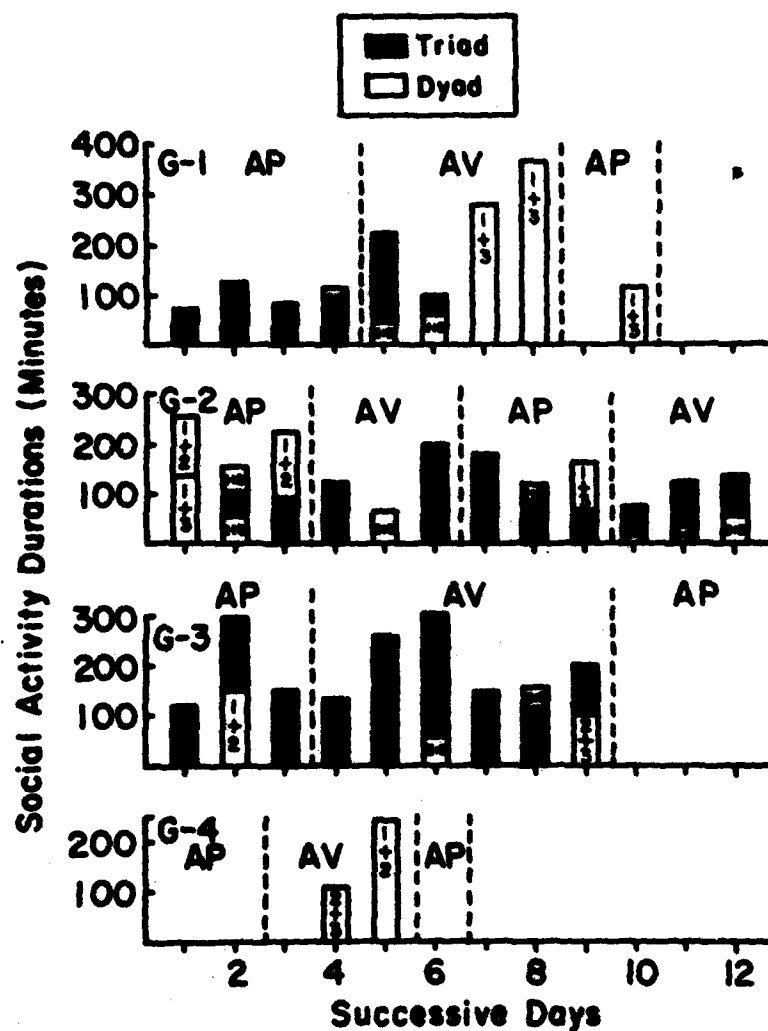


Figure 5. Social activity durations, both dyadic and triadic, for all groups across successive days of the experiment. The order of the social episode within a day is indicated by successive ordinal positions above the abscissa. Numbers within open bars denote pair members composing a dyadic episode.

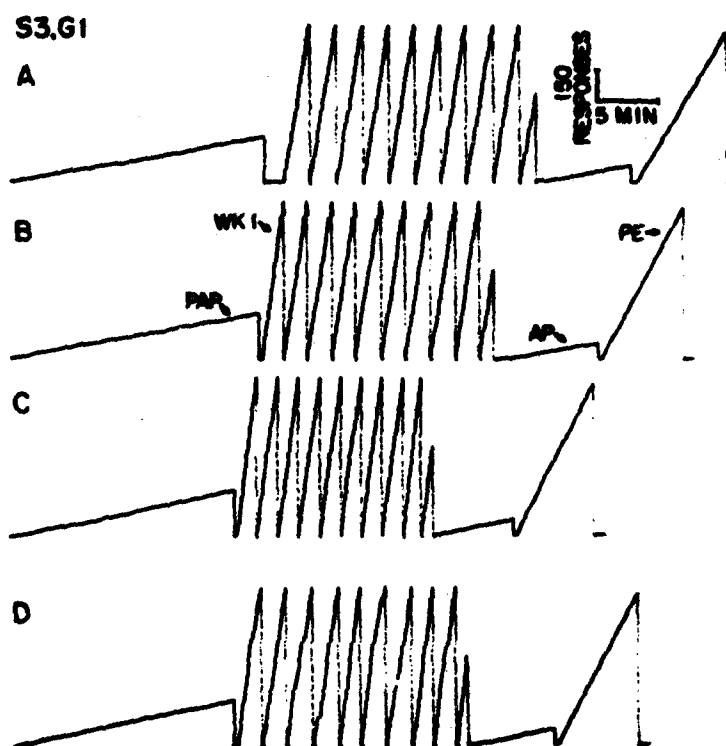
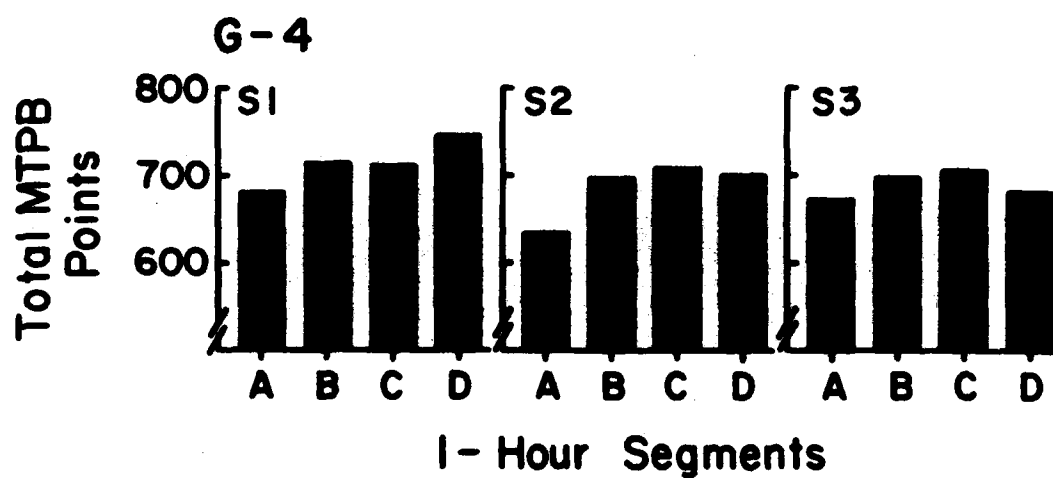


Figure 6. Cumulative records of 4 work trips completed by S3 in G1. See text for explanation of A-D.

trips completed by S3 in G1. The first and last work trips completed in the first appetitive period are denoted by records A and B, respectively. The last work trip completed in the avoidance period and the last work trip completed in the second appetitive period are denoted by records C and D, respectively. This figure graphically shows the stability<sup>b</sup> of the fixed ratio performances composing the work trip. Improvement in performance is indicated by progressively shorter times required to complete the trip across records A-C. No record shows evidence of fixed-ratio strain (e.g., pauses). Once the subject initiated a ratio run, performance was sustained at the prevailing steady state until the component was completed. Fine-grain performance was not demonstrably changed in relationship to the two reinforcement schedules. Similar processes were observed in the cumulative records of S1 and S2. No subject within Groups 1-3 failed to complete a trip once it had been initiated.

Figure 7 presents total NTPB points earned by all subjects within G4 across four distinct 1-hour segments of the experiment. These segments were composed of minutes 1-30 and 61-90 of a work episode. Minutes 31-60 had more stringent performance requirements to be discussed below. Segments from the first and last work episodes completed in the first appetitive period are denoted by A and B, respectively. Segments from the last work episode completed in the avoidance period and the last work episode completed in the second appetitive period are denoted by C and D, respectively. This figure indicates that performance progressively improved for S2 and S3 across Segments A-C and for S1 across Segments A, B, and D. The terminal performance presented in Segment D was highest for S1



**Figure 7.** Total MTPB points earned by all subjects within G4 across 4 1-hour segments of a work episode. See text for explanation of A-D.

whose behavior approached the limits of the task. Despite these differences, subjects were clearly more similar in their task performance than they were different. Finally, as indicated by Segment C, in comparison to other segments, the transition to asymptotic performance did not appear to be disrupted by the avoidance condition.

Table 1 presents fine-grain performance on the components of the MTPB for S1 within G4. The data represent mean performance across 4 consecutive 30-minute intervals for all work episodes completed within successive reinforcement conditions. One such interval occurred during the second 30 minutes of a work episode when a High Performance Probe (HPP) was in effect such that signal and task misses, false alarms, and errors produced a reduction in accumulated points. Throughout the remaining intervals of work, only false alarms diminished points. The table entries show that all tasks within the battery were performed by the subject during any given interval presented. Errorless performance was never observed, showing that the battery and its associated parameters continued to challenge the subject even after many hours of practice. However, performance effectiveness was demonstrably sensitive only to the demands of the HPP. During the HPP, the subject showed an increase in false alarms on the Probability Monitoring task (D), perhaps the most difficult task to operate. Further, the subject showed a striking increase in failures to respond (i.e., misses) on the Target Identification task (T) during the HPP. Similar effects were observed in the data of S2 and S3, although S2 did not show misses on the T task during the HPP. The performance data for S2 and S3, along with physiological reactions to the HPP, can be found in a

TABLE 1  
MTPB PERFORMANCE DATA FOR SUBJECT 1

MTPB PERFORMANCE DATA FOR SUBJECT 1																																											
A																T								W								B											
P				A				T				W				B				FA				L				M				H				FA				L			
N		M		FA		L		R		W		M		L		H		N		FA		L		H		M		FA		L		H		N		FA		L					
1.																																											
34.9		9.5		14.3		51.2		56.5		3.5		0.0		11.7		24.0		4.0		0.0		87.5		0.0		0.3		1.0		32.8		1.5		3.3		8.1							
11.																																											
48.3		4.0		33.0		39.9		55.5		4.3		0.3		11.6		15.5		2.0		10.5		92.3		0.3		2.3		0.7		34.5		2.3		4.5		7.4							
111.																																											
32.3		12.0		18.0		44.1		56.0		4.0		0.0		11.8		23.0		4.3		0.8		89.3		1.0		0.5		1.1		34.8		1.3		2.5		7.7							
IV.																																											
34.0		10.8		18.8		49.7		56.0		3.3		0.5		11.2		23.5		4.3		0.8		78.8		0.3		0.3		1.1		33.3		1.5		2.3		7.8							
Mean																																											
37.4		9.1		21.0		46.2		56.0		3.8		0.2		11.6		21.5		3.7		3.0		87.0		0.4		0.9		1.0		33.9		1.7		3.2		7.8							
1.																																											
41.8		6.5		21.0		39.9		56.3		3.8		0.0		11.6		23.3		3.5		1.3		87.8		0.0		0.0		1.0		33.5		1.0		2.3		7.5							
11.																																											
53.5		1.8		34.5		37.0		57.5		2.5		0.0		11.8		22.5		2.8		2.8		83.8		0.3		3.3		0.6		32.5		2.0		1.8		8.2							
111.																																											
47.3		3.8		22.5		43.6		56.8		3.3		0.0		11.7		23.3		4.8		0.3		84.3		0.3		0.3		1.0		33.5		0.8		2.0		8.5							
IV.																																											
49.8		2.5		19.5		40.0		56.8		3.8		0.3		11.8		21.8		6.3		0.0		87.8		0.8		0.5		1.1		31.3		2.5		0.8		8.5							
Mean																																											
48.1		3.7		24.4		40.1		56.6		3.4		0.1		11.7		22.7		4.4		1.1		85.9		0.4		1.0		0.9		32.7		1.6		1.7		8.2							
1.																																											
54.5		1.0		11.5		32.0		53.0		6.5		0.0		12.6		24.0		9.0		0.0		86.5		0.0		0.5		1.0		34.5		1.0		4.0		9.3							
11.																																											
54.5		1.0		17.5		37.9		53.5		6.5		0.0		12.0		22.5		3.5		2.0		83.0		0.0		3.0		0.7		32.0		2.5		2.5		8.6							
111.																																											
56.0		1.0		26.5		30.1		57.5		2.5		0.0		12.8		22.0		5.0		1.0		96.5		0.0		0.5		1.0		33.0		2.0		0.5		9.3							
IV.																																											
57.5		1.0		18.5		32.7		58.0		2.0		0.0		11.5		22.0		4.5		1.5		84.0		0.0		0.0		1.1		31.0		2.5		1.5		7.8							
Mean																																											
56.6		1.0		18.5		33.2		56.5		4.4		0.0		12.2		22.6		5.5		1.1		87.5		0.0		1.0		1.0		32.6		2.0		2.1		8.8							

P=probability monitoring, A=arithmetic operations, T=target identification, W=warning light monitoring, B=blinking light monitoring, H=hits, M=misses, FA=false alarms, L=latency in sec, R=right, and W=wrong. I=first half hour, II=second half hour of high performance probe, III=third half hour, and IV=last half hour of work. AP=appetitive condition means, and AW=avoidance condition means.

Technical Report presented elsewhere (Emurian and Brady, 1979). In summary, then, fine-grain MTPB performance accuracy was not demonstrably changed in relationship to the two reinforcement schedules, although its sensitivity to change, if not disruption, was revealed by the decrements observed during the HPP.

Work Trips. Figure 8 presents total work trips for Groups 1-3 and total MTPB points for G4 for all subjects across successive days of the experiment.

For Groups 1-3, the work trip contingency maintained substantial productivity levels for all subjects irrespective of the program condition, and none of these groups failed to reach the criterion during avoidance days. No subject completed fewer than 2 work trips per day (e.g., S2, G2, Day 1), with a range of 2 to 16 trips (e.g., S2, G3, Day 12). Several subjects showed an increase in total trips during an avoidance period that followed an appetitive period (e.g., S2, G1; S2, G2; S3, G2; and S2, G3). Within Groups 1-3, total work trips were more evenly distributed within subjects across days during the avoidance condition than during the appetitive condition. A comparison between the two conditions of the differences between the highest and lowest daily work trip frequency, under the assumption that such differences approach zero when variability is absent, showed a significant effect of program condition ( $t=2.07$ ,  $df=28$ ,  $p<.05$ ). Finally, all subjects within G1 and G3 showed an increase in daily work trips during the final appetitive days of the study.

In G4, between- and within-subjects' differences were observed in



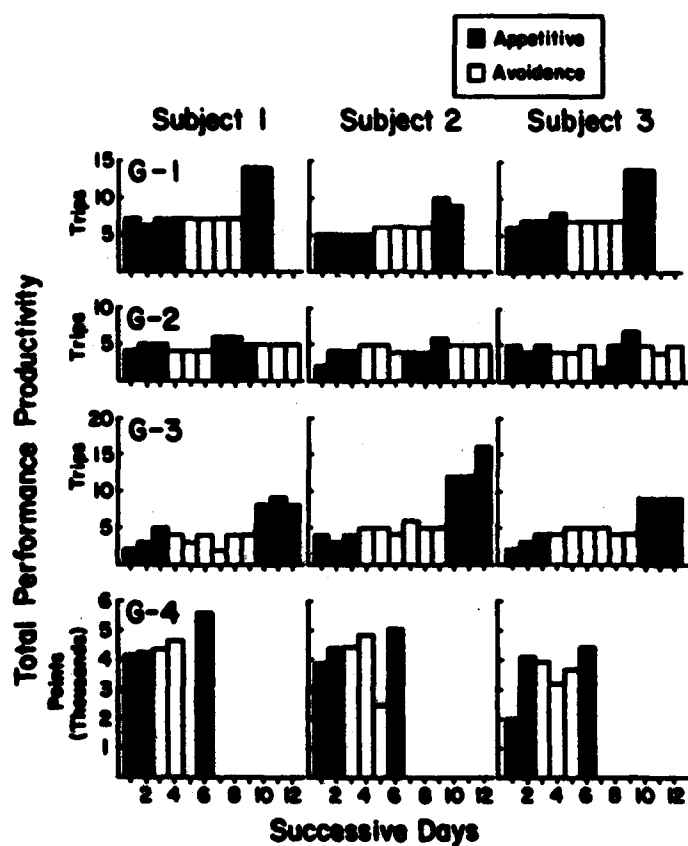
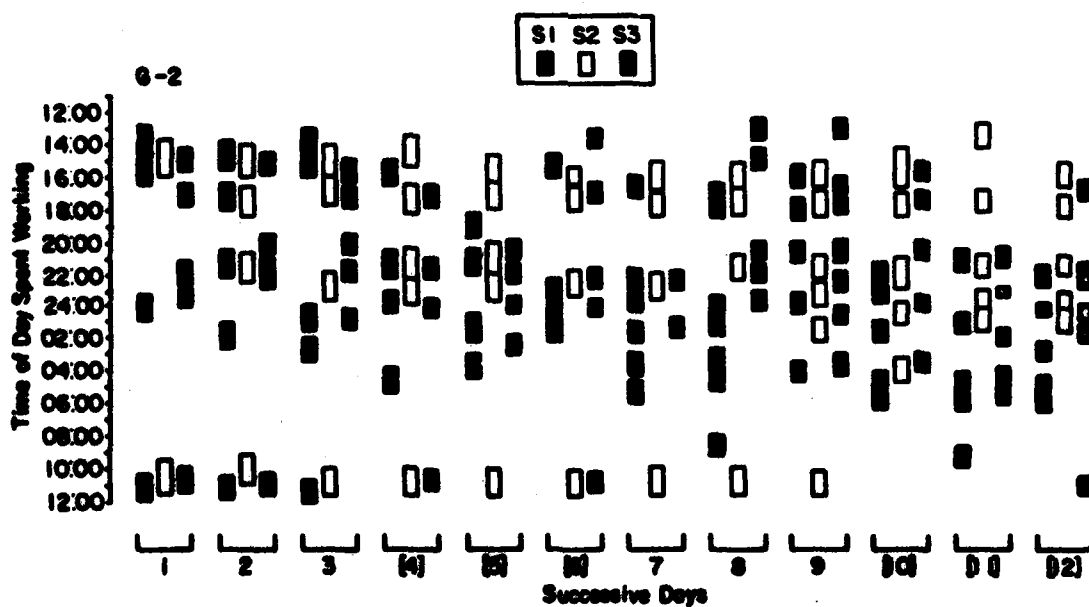
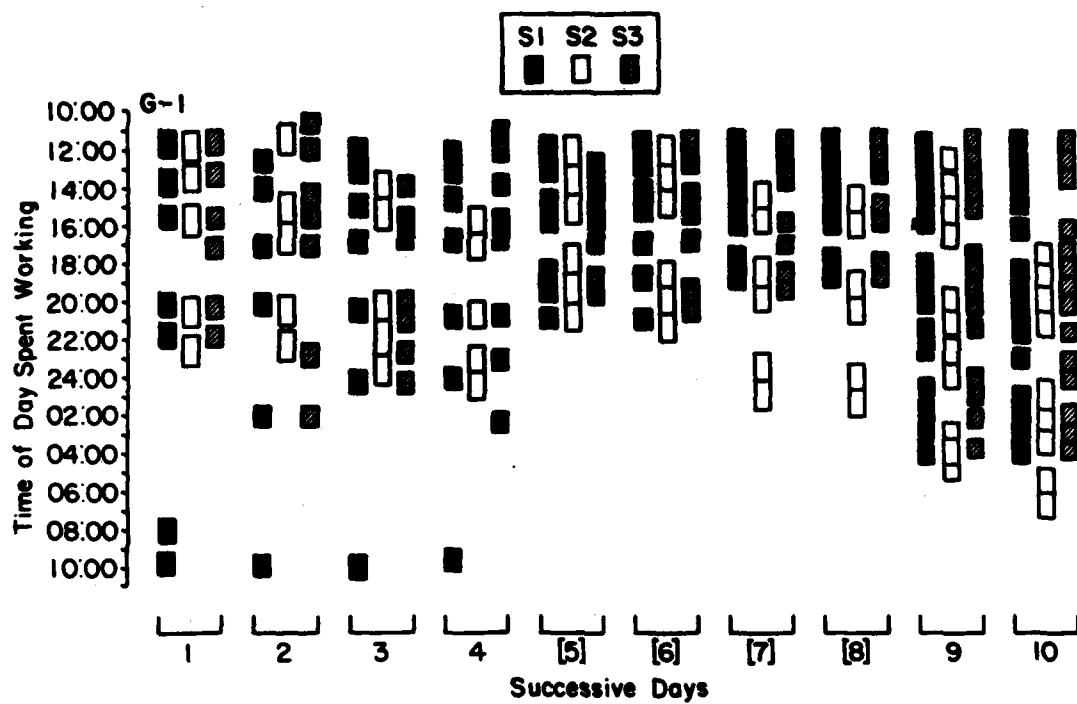


Figure 8. Total work trips for Groups 1-3 and total MTPB points for G4 for all subjects across successive days of the experiment.

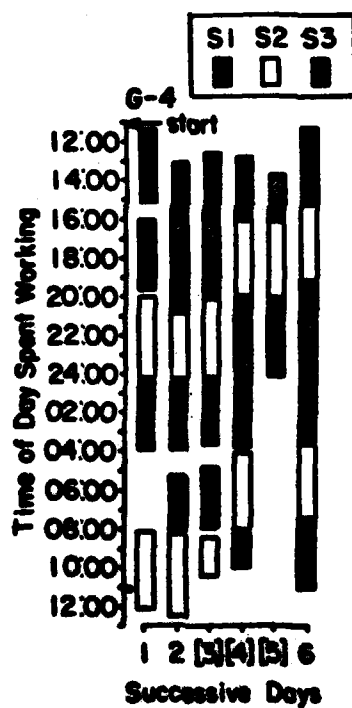
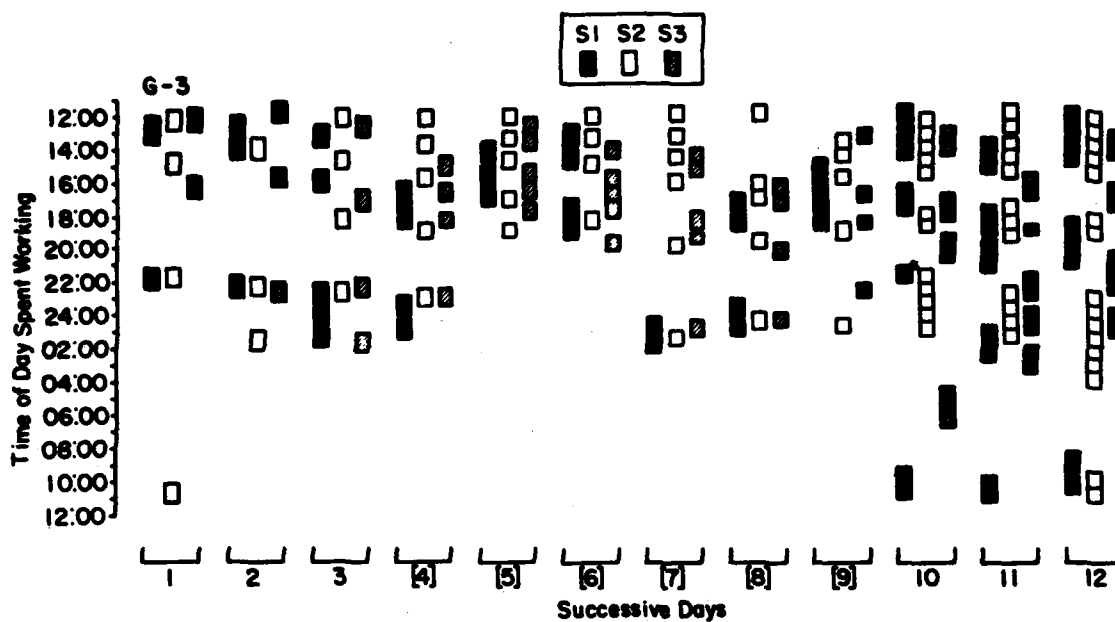
points produced per day on the MTPB. Variability in productivity among group members was evident on Day 1 when S3 contributed only 19.8% of the total points earned on that day, in comparison to 41.2% and 40.0% for S1 and S2, respectively. On Day 4, the second day of the avoidance condition, S3 fell behind in his share of work, as agreed upon by group participants, and the criterion was missed by 56 points. In response, S1 refused to perform any further work during the avoidance condition, whose duration was not known by the group, and on Day 5 the group lost heavily in potential earnings. Subject 2 also showed a markedly diminished output of work on Day 5. Neither S2 nor S3 showed a compensatory increase in work productivity on Day 5 that may have otherwise satisfied the criterion that was missed on that day by 6495 points. Finally, when the appetitive condition was reintroduced on Day 6, S1 and S2 again contributed to work, and like G1 and G3, all subjects showed the greatest daily point accumulations on that final day of the experiment.

Work Time. Figures 9-12 present time of day spent working for all subjects in Groups 1-4, respectively, across successive days of the experiment.

For Groups 1-3, work trips typically were completed between 1000 and 0200 hours of a day, and each work trip lasted approximately 1-2 hours. Figures 9-11 graphically indicate that subjects did not complete a day's work during a single uninterrupted succession of work trips. Rather, work trips were interspersed throughout waking hours, and other behavioral program activities were typically interposed between episodes of 1 or more



Figures 9 and 10. Time of day spent working for all subjects in G1 and G2, respectively, across successive days of the experiment. Avoidance days are bracketed.

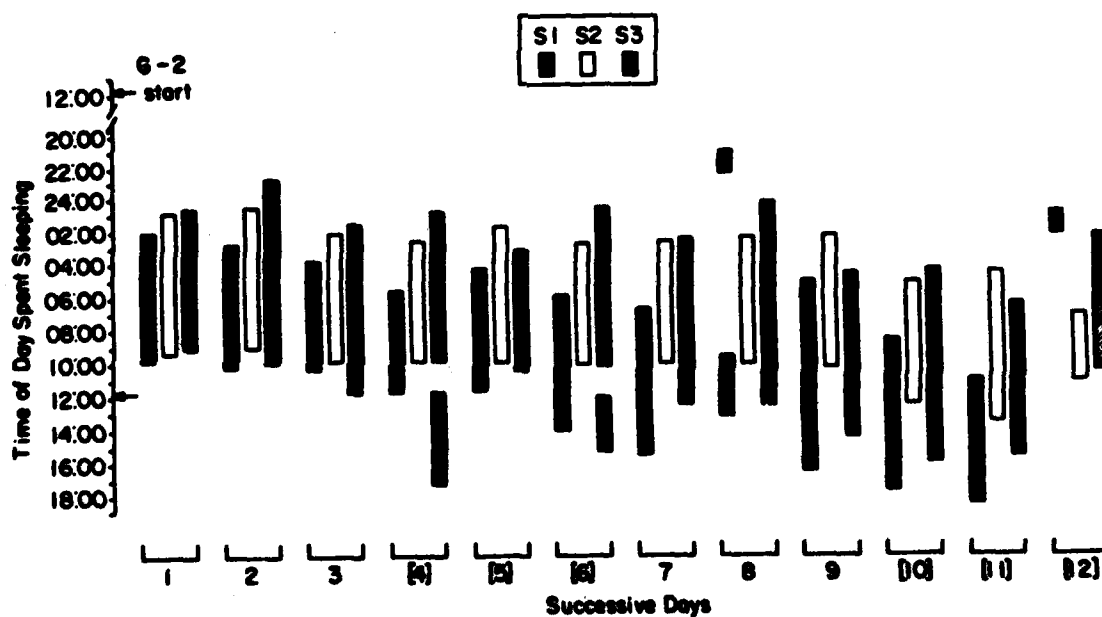
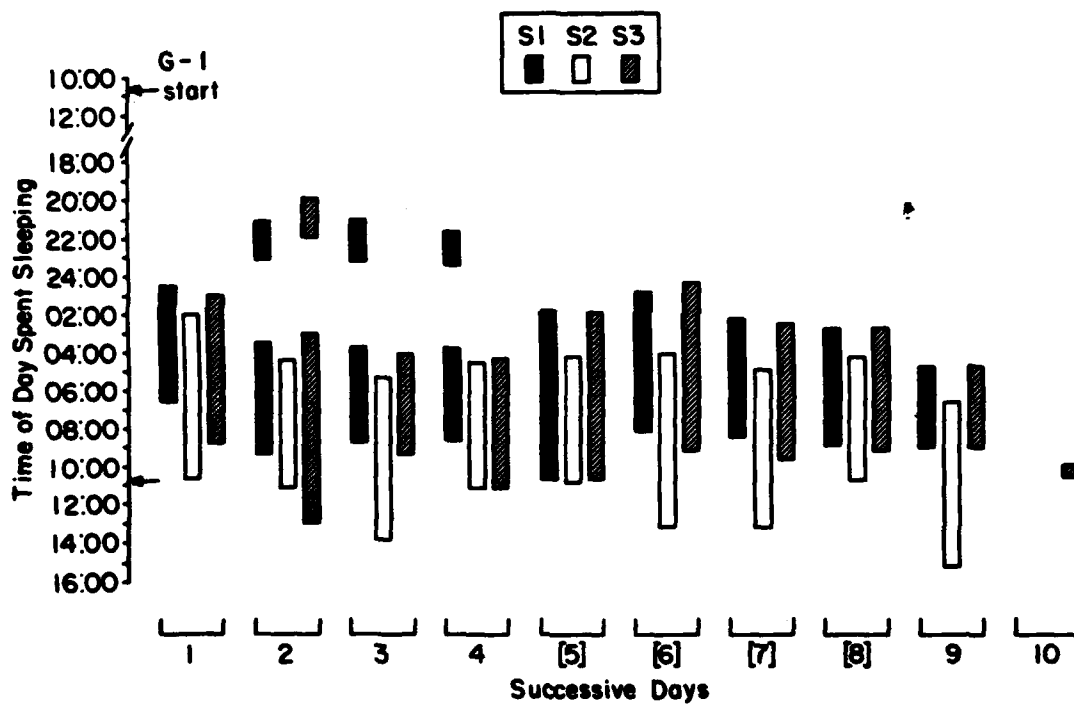


Figures 11 and 12. Time of day spent working for all subjects in G3 and G4, respectively, across successive days of the experiment. Avoidance days are bracketed.

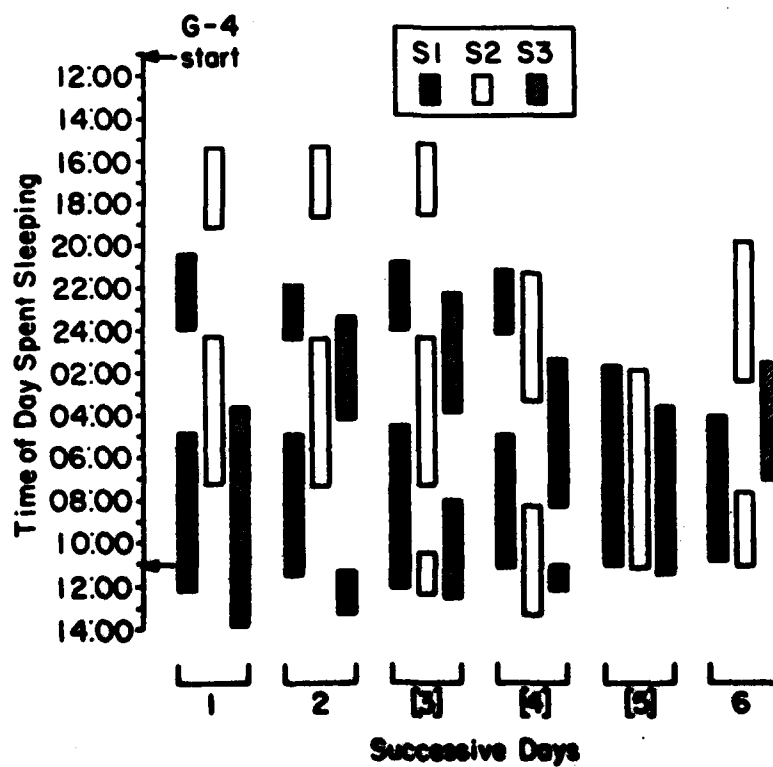
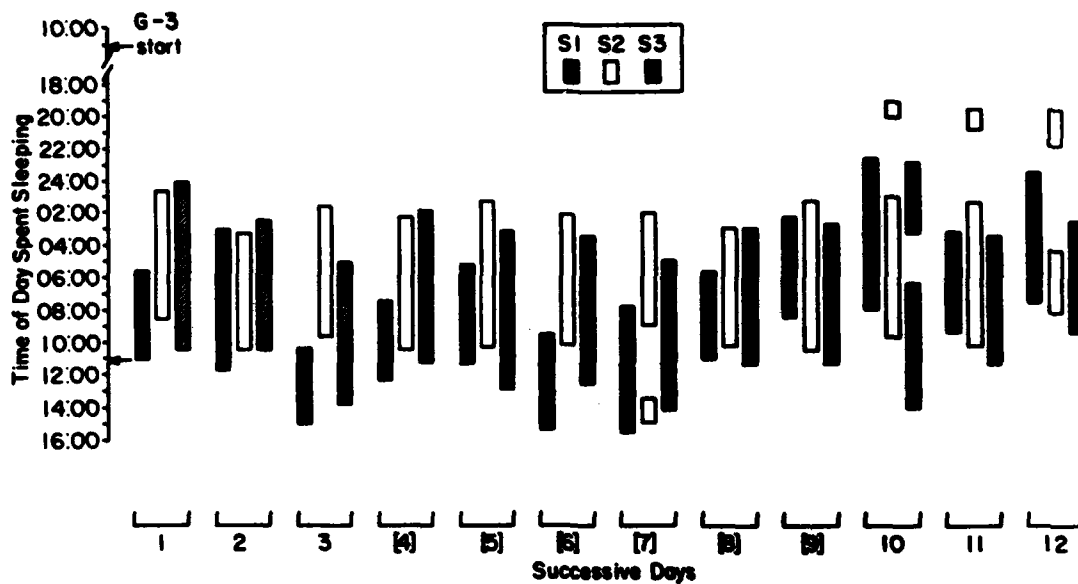
trips. Two groups showed a change in trip distribution when the avoidance condition was introduced (G1, Day 5; G3, Day 4). In comparison to trip distributions during preceding appetitive days, inter-trip-intervals appeared briefer on avoidance Days 5-8 for G1 and avoidance Days 4-6 for G3. By comparison, trip distributions by G2 were irregularly spaced across successive days. On the final appetitive days for G1 and G3, a greater number of successive trips were completed without a pause than was observed during preceding appetitive and avoidance days.

For G4, Figure 12 shows that subjects initially adopted an orderly and alternating sequence of using the single CRT console to operate the MTPB, with each uninterrupted work episode lasting approximately 4 hours. A "day" is bound by arrows on the ordinate, and the ordinate was extended downward to show work episodes that persisted across the boundary between successive days. During the first 3 days, there was almost perfect day-to-day agreement for the time of day when each subject worked. On Day 4, the second avoidance day, S2 and S3 switched positions from the previously established pattern, with S3 now working later in the day in comparison on his work times during the preceding days. On Day 5, S1 failed to work, S2 worked on 1 occasion, and S3 worked on 2 occasions. On Day 6 when the appetitive condition was reintroduced, subjects adopted an alternating work sequence identical to that on Day 4. Finally, only S1 maintained a consistent time of day when he worked across successive days of the experiment.

Sleep Time. Figures 13-16 present time of day spent sleeping for all



Figures 13 and 14. Time of day spent sleeping for all subjects in G1 and G2, respectively, across successive days of the experiment. See text for explanation of arrows on the ordinate. Avoidance days are bracketed.



Figures 15 and 16. Time of day spent sleeping for all subjects in G3 and G4, respectively, across successive days of the experiment. See text for explanation of arrows on the ordinate. Avoidance days are bracketed.

subjects in each group across successive days of the experiment. A "day" is bound by arrows on the ordinate, and the ordinate was extended downward to show sleep periods that persisted across the boundary between successive days.

For Groups 1-3, sleep typically occurred during a single daily episode, and "naps" were infrequent (e.g., S1, G2, Day 8). Subjects differed in stability of wake-sleep cycles over days. Some subjects showed modest regularity over days (e.g., S2, G3), other subjects showed a drift in cycles (e.g., S1, G2), and still others showed somewhat erratic cycles (e.g., S1, G3) across successive days. Almost all sleep periods exceeding 6 hours in duration began after 2400 hours.

As shown in Figure 16, wake-sleep cycles for subjects in G4 were broken and unstable across successive days. Sleep episodes typically were less than 8 hours in duration, and more than 1 sleep period occurred per day for most subjects. Subject 1, however, adopted brief but stable sleep periods across Days 1-4, in comparison to sleep periods exhibited by S2 and S3. On Day 5, S1 abandoned his previously established pattern. These effects are attributable, at least in part, to the style of alternating work that the subjects initially adopted to operate the MTPB around the clock.

Audits. The Audit activity in the behavioral program was freely available, and whenever a subject requested an audit, all three subjects' cumulative performance scores (trips for Groups 1-3, points for G4) for that day were presented on a CRT. Scores were reset to zero at the



beginning of each day. Figure 17 presents total audit responses for all subjects in each group across successive days of the experiment. This figure shows that access to performance scores was a reinforcer for almost all subjects (S1 in G2 was the exception). Most prominent in these data is the intersubject variability in audit responses with a range of zero (S1, G2) to 2 to 17 audits (S2, G1) between subjects across days. Total audit responses were not demonstrably affected by the two reinforcement conditions. Intersubject variability in total audits was related to variability in other response domains as discussed below.

Estimates of Comfortable Residence. During each Health Check activity, a subject estimated how many days he or she could live comfortably in the programmed environment irrespective of the planned duration of the experiment. Table 2 presents pairs of the highest and lowest estimates for all subjects in each group across successive days of the experiment. All subjects showed differences between high and low estimates on a given day with a range from 1 difference (S3, G1, Day 4) to 12 differences (S3, G2, Days 1-12). Eight of the 12 subjects ended the experiment with high estimates equal to (i.e., S3, G4) or far exceeding (e.g., S3, G1) the duration of the experiment. All members within two groups (G2 and G4) ended the experiment with high estimates that exceeded those on Day 1, and members in G2 showed terminal high estimates that were lower than those on Day 1. In G1, S1 showed no change, S2 showed a reduction, and S3 showed an increase in high estimates between Days 1 and 10. Estimates did not appear demonstrably affected by the two reinforcement schedules, with the exception of the final three avoidance

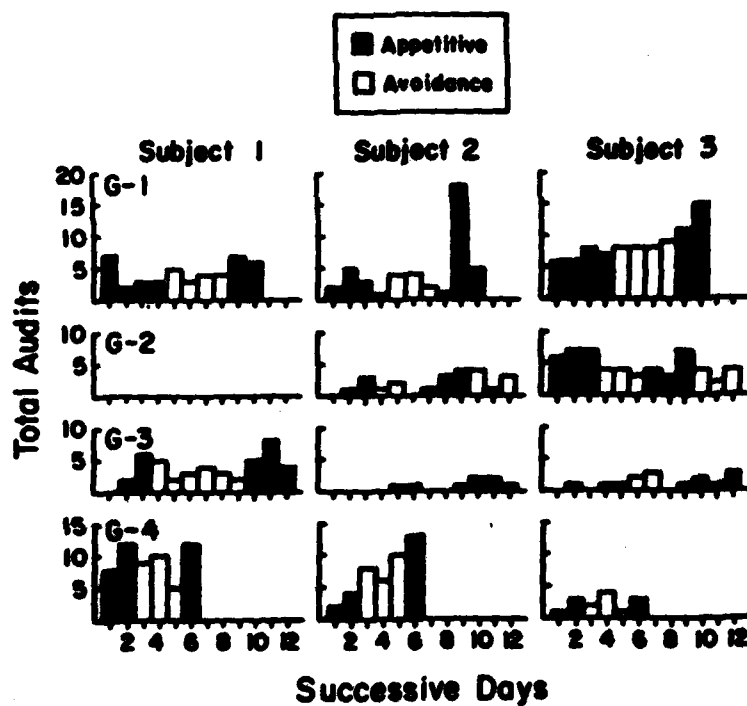


Figure 17. Total audit responses for all subjects in each group across successive days of the experiment.

TABLE 2

ESTIMATES OF COMFORTABLE RESIDENCE IN DAYS <sup>1</sup>												
SUCCESSIVE DAYS												
	1	2	3	4	5	6	7	8	9	10	11	12
61	S1	*	*	*	*	*	*	10	*	*		
		*	30	30	14	14	10	0	0	3	2	
	S2	10	10	10	10	128	8	5	4	5	1	
		10	10	10	9	8	1.5	4	3	2	0	
	S3	30+	30+	30+	*	*	*	*	*	*	*	
		30	30+	30	30+	*	*	*	*	*	*	
62	S1	100	100	100	*	*	100	100	100	100	100	0
		100	100	100	100	100	100	100	100	100	0	0
	S2	15	12	10	12	10	10	10	9	10	3	0
		12	10	10	9	8	8	6	6	0	0	0
	S3	20	25	20	20	10	8	7	8	500	4	1
		12	12	10	1	8	1	4	4	2	2.3	0
												0
63	S1	30	30	27	26	24	24	23	22	21	19	18
		30	28	26	25	24	23	22	22	2	2	0
	S2	60	60	60	120	120	90	120	120	120	120	90
		60	60	60	60	90	90	90	60	60	90	30
	S3	12	12	15	15	15	20	30	45	30	30	30
		12	12	12	12	12	2	12	30	34	35	30
												60
64	S1	*	*	*	14	14	14					
		0		0	10	10	10					
	S2	*	30	30	30	20	20					
		30	30	30	20	20	15					
	S3	10	10	10	10	6	6					
		10	7	7	5	5	5					

1. For each pair entry, the top number is the high estimate, and the bottom number is the low estimate. Avoidance days are bracketed.  
 \*=infinity.

days in G2. Finally, 5 of the 12 subjects ended the experiment with high estimates equal to or greater than 2 months.

Mood Ratings. During each Health Check activity, each subject completed a "mood" questionnaire (Lorr, Daston, and Smith, 1967). Figure 18 presents mean ratings on the "Depression" factor for all subjects in each group across successive days of the experiment. Ten of the 12 subjects showed the highest rating during the avoidance condition (S2, G2 and S3, G4 were the exceptions), and the overall differences between the conditions were significant ( $t=3.22$ ,  $p<.02$ ),  $df=11$ ).

Urine Free Cortisol. For subjects in G3 and G4, total urine volumes were collected and assayed for cortisol by radioimmunoassay (Mougey, 1978). Urine aliquots were extracted with ethyl acetate, and aliquots of the ethyl acetate layer were evaporated and assayed for free cortisol by radioimmunoassay using an antibody produced in rabbits against cortisol-3-(0-carboxymethyl) oxime: BSA conjugate. This antiserum was collected six months following primary immunization and was used at a dilution of 1:80,000. Using the addition of 5 ng of steroid as a reference, 11-deoxycortisol cross reacted 35%, cortisone 12%, testosterone less than .5% and most other urinary steroids less than 2%. Assay sensitivity was 50 pg. Intra-assay variation was 6%, and interassay variation was 10%. Separation of free from bound steroid was by Somogyi reagent precipitation of the antibody bound fraction.

Table 3 presents micrograms of urine free cortisol for all subjects in G3 and G4 across successive days of the experiment. Examination of Table 3

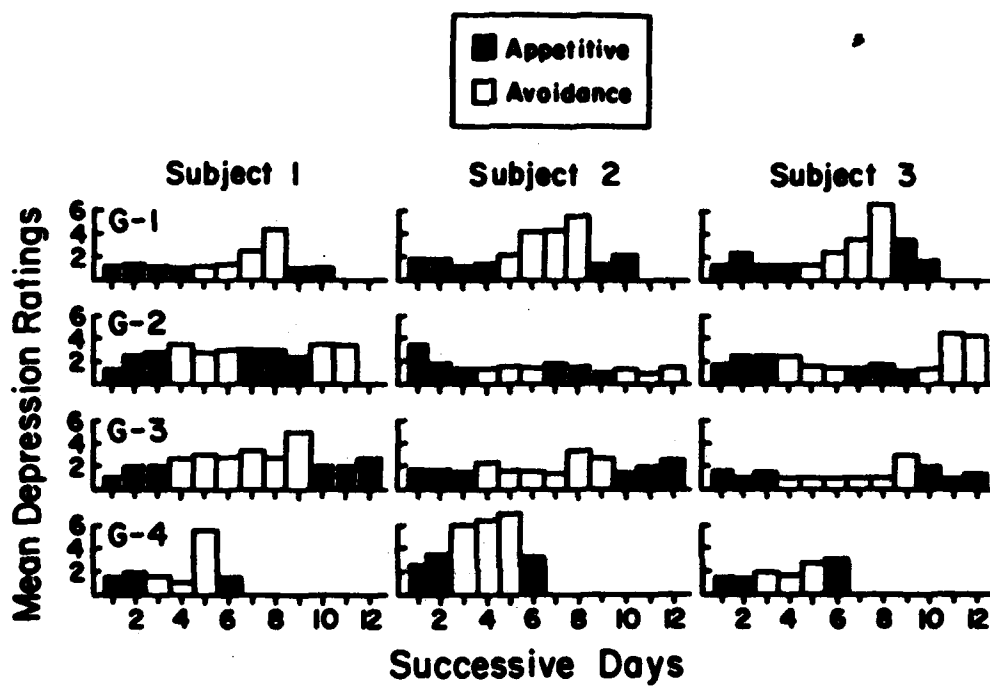


Figure 18. Mean ratings of "depression" for all subjects in each group across successive days of the experiment.

TABLE 3

URINE FREE CORTISOL (MICROGRAMS)													
SUCCESSIVE DAYS <sup>1</sup>													
	1	2	3	4	5	6	7	8	9	10	11	12	Mean
S1	46	49	65	<u>/62</u>	51	67	55	56	<u>80/</u>	46	49	81	58.9
G3 S2	19	25	21	<u>/21</u>	17	13	27	35	<u>24/</u>	30	23	45	25.0
S3	23	32	34	<u>/32</u>	33	35	40	37	<u>29/</u>	36	32	35	33.2
S1	76	65	<u>/64</u>	71	<u>65/</u>	63							65.8
G4 S2	29	87	<u>/49</u>	67	<u>61/</u>	63							59.3
S3	31	47	<u>/32</u>	40	<u>41/</u>	45							39.3

1. Avoidance days are bracketed.

indicates that cortisol levels were not demonstrably affected by the two reinforcement conditions, nor was there a demonstrable trend in cortisol levels across successive days. Differences are apparent, however, among the subjects. The two subjects with the highest overall means per day were males (S1 and S2, G4), and the two subjects with the lowest overall means per day were females (S2 and S3, G3). These differences are consistent with differential responses to the avoidance condition as discussed below.

#### DISCUSSION

The results of the present experiment show that changing the consequences of performing a task from an appetitive to an avoidance schedule of reinforcement produced by-products of aversive control. These latter effects included non-socially evoked verbal performances (e.g., behavioral program and "mood" ratings), socially evoked verbal performances (e.g., intersubject and experimenter ratings), and work performances (e.g., trip distributions between and within subjects). And in the fourth group, one subject stopped working, and a second subject reduced his productivity during the avoidance condition. When the work incentive was changed from avoidance to appetitive, such deleterious by-products were eliminated or reduced in intensity despite a group's several-day history of working under aversive control. These effects suggest that the functional properties of work (i.e., consequences) were far more significant to the group members' well-being than were the topographical properties (i.e., behaviors required to perform work).

Although effects of an avoidance schedule were evidenced with only a

single multiple reversal experimental design (i.e., A-B-A-B with G2), the changes that occurred during a second appetitive condition in all groups, in contrast to effects observed during prior avoidance days, suggest control by that negative reinforcement schedule rather than control attributable to the passage of time within the laboratory environment or to other processes. In comparison to very long duration studies employing multiple reversals with a large sample of subjects, the present design was chosen as a compromise procedure that could nevertheless demonstrate effects and yield meaningful information with acceptable scientific rigor, given the realistic constraints and expense of undertaking such research with human volunteer participants. Indeed, in G2 that ended with the avoidance condition still in effect, the initial displeasure of the subjects was sufficiently intense to preclude further experimental analyses with such an identical multiple reversal of the two reinforcement schedules.

It should be emphasized, however, that these observations were conducted under conditions that were never so disturbing to a person as to warrant termination of a study, and, as indicated by estimates of how long a subject could remain comfortably within the laboratory, few subjects expressed the disposition to reduce a study's duration. At the conclusion of a study, staff and subjects met together for a debriefing session, and a cordial atmosphere existed when subjects departed the laboratory.

The present experiment consisted of four systematic replications in which control by the avoidance schedule was demonstrated by affirming the



consequent (Sidman, 1960), in which case each successive replication incrementally contributed to an understanding of effects that can be reliably attributable to the antecedent condition (i.e., the avoidance schedule). The generality of the behavioral processes is indicated by showing similar effects across a broad range of circumstances (e.g., subjects, duration of experiment, work tasks, order of experimental conditions, etc). Although all members within the groups studied showed at least some identical reaction to the avoidance schedule (e.g., spoken and written complaints), the interpersonal confrontations were most prominent within those groups (G1 and G4) having an assertive member who was at least unappreciative, if not openly intolerant, of intersubject variability in work productivity during the avoidance condition. Other human operant studies have suggested that inequity (i.e., intersubject variability) in reinforcers is a noxious stimulus within a social exchange paradigm (Marwell and Schmitt, 1975; Shimoff and Matthews, 1975), and social psychologists have reported relationships between inequity and human anger (e.g., Adams, 1963, 1965; Ross, Thibaut, and Evenbeck, 1971) and "frustration" and human anger (e.g., Berkowitz, 1981). This suggests that an extraneous source of variability in accounting for strong and weak effects of the avoidance schedule is to be found in intersubject sensitivity to inequity in performance maintained under aversive control, since the present contingency compensated subjects equally irrespective of differences in productivity. The extent to which individual differences may be characterized as a behavioral datum must await clarification by further analyses of the interactions between reinforcement schedules and

personal history variables.

The presence of noxious stimulation within the subjects' environment was also indicated by affirming the consequent. Although the negative reinforcement schedule had operational parameters (i.e., an avoidance criterion), it would not be possible to specify and quantify the physical properties of such stimulation in a moment-to-moment relationship with the subjects' behavior (Skinner, 1953, p. 171). The extensive conditioning history of the participants must be invoked to account for their sensitivity to an avoidance contingency whose determinants involved conditioned reinforcers acting in a distant temporal relationship with the subjects' behavior. The continuity of behavioral processes, however, is suggested by subjects' reactions to the avoidance schedule that are similar to results of other studies showing aggressive responses in relationship to precisely quantifiable noxious stimulation within both social (e.g., Azrin, Hutchinson, and Hake, 1963) and non-social paradigms (e.g., Azrin, Rubin, and Hutchinson, 1968). Additionally, fixed-ratio schedule-induced aggression has been reported (Cherek and Pickens, 1970; Flory, 1969; Gentry, 1968; Hutchinson, Azrin, and Hunt, 1968; Lyon and Turner, 1972; Webbe, DeWeese, and Malagodi, 1974), although recent analyses have emphasized the temporal patterning of reinforcers as eliciting events (DeWeese, 1977). Moreover, both fixed-ratio and extinction-induced aggression has been reported with pigeons (Knutson, 1970), and extinction-induced aggression has been reported with humans (Kelly and Hake, 1970). All these factors suggest that the present findings may be incorporated within the general conceptual framework that encompasses the

analysis of by-products of aversive control (Hutchinson, 1976; 1983), and they suggest that similar variables are operative.

The earliest indication of subjects' sensitivity to the presence of an aversive reinforcement schedule was in the form of verbal responses. Recurrent written responses by subjects reflected complaints about the aversive contingency when it was first introduced, and such expressions of discontent usually increased in magnitude across the duration of the aversive condition. These written responses, along with anecdotally observed vocal complaints about the aversive contingency, are categorized by their functional properties as a mand (Skinner, 1957), and they emerge because similar verbal responses have been effective historically in eliminating aversive events from one's environment. These data, then, suggest the importance of frequent and systematic assessment of subjects' descriptions of their environment so that the necessary adjustments may be undertaken to prevent a crisis situation such as occurred on Day 5 of the fourth experiment.

Within those groups in which intermember tensions predominated (i.e., G1 and G4), the interpersonal effects were associated with a reduction or absence of social interactions. For example, S2 within G1 failed to participate in either dyadic or triadic social episodes from Days 7 through 10 (See Figure 5). Subjects within G4 never participated in a triadic social episode, and neither of the two dyadic episodes involved S1 and S3 who showed most mutual annoyance. Relationships between interpersonal incompatibility and social interactions have been reported in other studies

of group behavior under conditions of isolation and confinement (e.g., Altman and Haythorn, 1967). With respect to the contingencies for social episodes in the present experiment, non-cooperation contingencies, providing access to FD3 and WK3 alone or with one or two other subjects, were deliberately programmed so that dyadic and triadic episodes could serve as dependent variables and thereby participate in a functional analysis in relationship to other observations. It would be of interest, then, to determine the strength of cooperation contingencies, requiring all group members to select a recreation area concurrently, in preventing interpersonal side-effects that emerged under aversive control. The effective application of cooperation contingencies to prevent group fragmentation and social isolation has been previously demonstrated (Emurian, Emurian, Bigelow, and Brady, 1976; Emurian, Emurian, and Brady, 1978).

The only local effects of the two reinforcement schedules on the work performance baseline were reflected in trip distributions. Subjects within G1 and G3 sometimes showed more rapid completion of work, in relationship to the start of a day, during avoidance days than during preceding appetitive days. These effects are consistent with fixed-ratio avoidance performances where the ratio run in a multiple schedule occurred soon after component onset (Morse and Kelleher, 1966). The exceptions were the cessation of work (S1, G4) and the diminution of work (S2, G4) by two subjects in G4 during the last day of a three-day avoidance condition. Withdrawal from a social exchange relationship has been suggested as a possible outcome when inequity cannot be overcome (Adams, 1965), and in G1

and G4, "high productivity" subjects were apparently unsuccessful in persuading the "low-productivity" subject to increase markedly his output during both appetitive and avoidance days. That S1 in G4 remained "involved" with the group, however, was indicated by his audit responses on Day 5 when he refrained from work. Moreover, at least one, "low-productivity" subject (S2, G1) increased his output during the avoidance condition, and both S2 in G1 and S3 in G4 showed the highest work output during the final appetitive days, as did all ten remaining subjects. These latter effects occurred without deleterious by-products, and they indicate that performance productivity was not the source of negative reactions.

The insensitivity of the work performance baseline to disruption once work was in progress is consistent with previous analyses of the resiliency of fixed-ratio performances in relationship to reinforcer proximity in a conditioned suppression paradigm (Lyon, 1964) and to the intensity of punishment (Azrin, 1959; Dodd, Williams, Bissel, and Weisman, 1977) and low values of a DRO (Zeller, 1979) required to disrupt performance. Subjects exhibited the characteristic fixed-ratio "break-and-run" pattern (Ferster and Skinner, 1957): once work was initiated after a pre-ratio pause (Griffiths and Thompson, 1973), performance persisted at a high and steady rate until completion of a trip(s) or several hundred MTPB points. Diminution in performance productivity, when observed, was attributable to less frequent work trips or MTPB episodes (e.g., S2, G4, Day 5). Similar fixed-ratio processes with humans have been reported previously (Long, Hammock, May, and Campbell, 1968; Weiner, 1970; Poppen, 1982). The overall

stability of accurate work performances, in contrast to the development of deleterious by-products of aversive control, suggests that a fine-grain analysis of such performances could be complemented by other data in determining the capability of a micro-society to sustain such performances indefinitely without untoward effects (cf. Chiles, Alluisi, and Adams, 1967).

The above observations show the importance of obtaining many distinct measures in the course of a behavior analysis in that intersubject and/or intrasubject variability observed within one response domain may be interpretable in relationship to variability observed within another domain. For example, the two subjects (S3, G1 and S1, G4) who exhibited consistent high rates of auditing, in comparison to other subjects, were also most prominent in intersubject confrontations during avoidance days. These two response domains may be functionally related: an initially high rate of interpersonal auditing under conditions of positive reinforcement may indicate, as a behavioral "marker" of individual differences, sensitivity to disruptive reactions when inequity exists under conditions of negative reinforcement. The importance of measuring several concurrent responses has also been demonstrated with human behavior analyses where a person's rate of auditing his and another's performance "score," produced within the context of a dyadic social relationship, was interpretable in terms of other observations (Hake, Vukelich, and Kaplan, 1973; Vukelich and Hake, 1974). High rates of auditing in both situations may be functionally related to a subject's low level of "trust" that an equitable relationship between work and reinforcers will prevail over time (Hake and Schmid, 1981;

Schmid and Hake, 1983). A multidimensional strategy also proved productive in other studies of group behavior under isolated conditions (Altman, Taylor, and Wheeler, 1971).

The group (G3) whose members showed weak by-products of aversive control was composed of females. Had the avoidance condition for G3 persisted beyond 6 days, perhaps stronger effects than those observed would have emerged eventually. The appetitive condition was reintroduced for the final 3 days in G3 to maintain procedural comparability with other groups, to provide the opportunity for a terminal "burst" of responding, and to provide the opportunity for dissipation of those by-products that were observed. Although it is provocative to relate the observed differences in outcome between the males and females to a "gender effect," such an interpretation in the present analysis is perhaps overly simplistic.

In a recent review of research studying sex differences in anger and aggressiveness, the similarities between men and women were far more striking than the differences (Averill, 1982). To interpret the present findings, it would likely prove revealing to search for potential sources of variability, other than gender, among the group members such as education, vocation, economic need, sociability, personality, and achievement motivation (Helmreich, Spence, Beane, Lucker, and Matthews, 1980), among many others. Although subjects were selected from a relatively homogeneous population, no attempt was made to control such extraneous sources of variability, some of which have been very carefully controlled as independent variables in "large-N" studies of individual and

group adjustment under conditions of isolation and confinement (Smith and Haythorn, 1972). The very fact that differences in response strength emerged during the present four systematic replications suggests the importance of subject selection criteria (Jones and Annes, 1983) as they interact with the functional properties of the behavioral program in influencing sensitivity to aversive control conditions. A tactical advantage of systematic replication in the developing stages of a research program, then, is the opportunity afforded to uncover effects over a range of basically similar circumstances without risking discouragement by observing idiosyncratic weak effects across a succession of direct intersubject replications.

The results of the cortisol analyses as they relate to other observations of by-products of aversive control suggest that interactive behavioral and biological processes are involved in the individual performance adjustments and social adaptations of small groups in a confined microsociety. For example, subjects with higher cortisol levels (G4) tended to display stronger effects of the avoidance condition than did subjects with lower cortisol levels (G3). And it was the case that the subject with the highest mean daily cortisol level (S1, G4) was also the subject who withdrew from work during the avoidance condition. This suggests that sustained high productivity along with prolonged performance accuracy on a demanding task may render an individual vulnerable to disruptive emotional reactions such as those provoked by the avoidance condition. Finally, these observations are generally consistent with the catabolic influence presumed to be exerted by cortisol on energy metabolism



(Mason, 1968), and cortisol excretion has been implicated in relationship to "stressful" events (e.g., Ursin, Baade, and Levine, 1978).

The practical significance of the present study is to be understood in terms of providing guidelines for the assessment of a small-scale human micro society. When untoward effects are observed, it may only be prudent to treat those effects as "early warning signs" that aversive control variables are operative (cf. Weick, 1977). Under such circumstances, interventions could occur to prevent a performance decrement such as occurred with G4 when by-products of the avoidance schedule were allowed to persist unchecked for 3 successive days. More significantly, perhaps, the present study shows the importance and adequacy of initially implementing positive reinforcement contingencies as "human engineering principles" in the design of micro societies.

What, then, are the indicators of the "health" of a confined micro society and its members? The present analysis suggests several. Stability or orderly transitions in wake-sleep cycles are required: people certainly need proper sleep to function effectively during wake periods. Routine physical exercise and proper nutrition are required. Recurrent and amiable social relationships among group members and between the group and external "authority" seem to be important. The opportunity for personal privacy and for the pursuit of recreational and intellectual endeavors likely makes its contribution. Group members should be happy, free from dysphoric mood, and disposed to remain within their surroundings. And of perhaps paramount importance is the capability of group members to maintain

high levels of performance effectiveness on tasks that are essential to the success of a "mission." How to maximize the dispositions of microneauts to perform in ways that are beneficial to themselves and to a "mission" is of critical importance. The behavioral program provides one promising structural and functional solution to the problem of motivating and monitoring individual and group behavior for the continuous observation and assessment of the status of a confined microsocociety.

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