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BEHAVIORAL AND BIOLOGICAL INTERACTIONS WITH SMALL GROUPS IN CONFINED MICROSOCIETIES

Annual

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Title: "Behavioral and Biological Interactions With Small Groups in Confined Microsocieties"

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I. BACKGROUND

Requirements for high levels of human performance in the unfamiliar and stressful environments associated with space missions necessitate the development of research-based technological procedures for maximizing the probability of effective functioning at all levels of personnel participation. Where the successful accomplishement of such missions requires the coordinated contributions of several individuals collectively identified with the achievement of a common objective, the conditions for characterizing a "team", "crew", or "functional group" are operationally defined. For the most part, studies of group performances under operational conditions which emphasize relatively long exposure to extended mission environments have been limited by the constraints imposed on experimental manipulations to identify critical effectiveness factors. On the other hand, laboratory studies involving relatively brief exposures to contrived task situations have been considered of questionable generality to operational settings requiring realistic group objectives. The research program for which this annual technical report is submitted has been concerned with the development of an experimental methodology for the study of such human individual and small group behaviors under residential "programmed environment" conditions.

II. OBJECTIVES

A. Development of principles and procedures for optimizing the selection and training of individuals and groups for participation in space mission performance programs under conditions of extended isolation in confined microsocieties.

B. Evaluation of behavioral and biological effects of group composition and organizational structure in confined microsocieties under conditions of extended isolation.

C. Assessment of performance effectivenes in small-group confined microsocieties under conditions of individual member substitution and/or replacement.

D. Development and evaluation of preventive monitoring and corrective procedures as countermeasures to the potentially disruptive influence of group turbulence on performance effectiveness.

III. APPROACH

A. Development of group tasks requiring concurrent and coordinated performances for several participants.

B. Determine optimum procedures for introducing and integrating mission participants into functionally performing groups and established organizational units.

C. Compare alternative "pre-flight" orientation programs with particular reference to individual participants in transition to established organizational settings with assigned missions.

D. Analyze behavioral and biological influences in small-group confined microsocieties under conditions of individual member substitution and/or replacement.

E. Provide and refine guidelines relevant to the orientation, formation, and reorganization of operational space mission units.

IV. RESEARCH PROGRESS

Experiments completed during the initial year on this grant have extended previous studies on the analysis of "introduction" effects observed when a novitiate member is added to an existing group of individuals involved in operational performances in a residential laboratory setting. In the series of experiments to be described in the present report, an analysis of "replacement" effects has been undertaken. Whereas the previous investigations changed group size as an experimental variable or treatment, the most recently initiated studies held group size constant to evaluate effects of replacing a member of an established three-person group with a novitiate participant. These replacement analyses, then, involved important elements of continuity with the earlier studies in the manner of being systematic replications of those investigations.

A typical replacement investigation proceeded as follows. An original three-person group resided in the programmed environment for five successive days. At the end of Day 5, one of the original group members was withdrawn, and he was replaced by a novitiate participant who, along with the remaining two original members, formed a new group for the next five successive days. Consecutive studies differed in terms of (1) the decision rule by which an original group member was withdrawn, (2) the number of baseline days that came before group formation, and (3) the type of performance tasks that the group members operated for compensation.

For the first replacement experiment (REPL 1), three-person group members resided in their private rooms for a two-day baseline "alone" period during which time access to the intercom, to social activities, and to the MTPB work station was prohibited. This two-day period provided a necessary hormonal reference against which to assess endocrine responses in relationship to initial group formation. On Day 3, all activities previously prohibited were made available to the group, and each member was required to operate the MTPB for individual compensation. As in the introduction experiments, there was only one MTPB console located within the workshop, and subjects occupied the workshop singly on a self-determined rotational basis. This procedure, then, permitted an evaluation of the manner in which subjects occupied the work station (e.g., duration of work periods, time-of-day of work periods, etc.) as one of the principal dependent variables of the experiment.

At the end of Day 5, whoever of the three mission members had earned the fewest MTPB performance points, totalled across Days 3-5, was withdrawn from the experiment. This decision rule was known by the group members before the experiment began. The novitiate participant entered the programmed environment on Day 6, which was a solitary baseline day for all three subjects. On Day 7, the newly formed team had access to intercom communications, social activities, and the MTPB work station that continued to be available throughout Days 7-10. Thus, the two ten-day participants were required to adjust to the replacement of an original member, and the novitiate member was required to adjust to his entrance into an established unit whose members shared a history of having competed successfully to maintain high levels of performance effectiveness.

Figure 1 presents time of day spent working on the MTPB for all subjects across successive days of the experiment when access to work was permitted. The novitiate participant is identified as "S4." Throughout Days 3-5, subjects alternated in their occupancy of the work station, with uninterrupted work periods ranging from 2 hours (e.g., S1, Day 3) to 9 hours (e.g., S2, Day 4). The lengthy work period exhibited by S2 on Day 4 was related to his attempt to remain competitive after having worked only 2 hours on Day 3. When the novitiate (S4) began to work on Day 7, having replaced S2, he initially preempted the work station for at least nine uninterrupted hours of MTPB performance. That the other group members were unappreciative of this intrusion was indicated quantitatively by the negative interpersonal ratings assigned to S4 during the Health Check activity. Thereafter, the novitiate and the remaining group members alternated occupancy of the work station, with S3 clearly showing work times later in the day in contrast to his work times during Days 3-5. Neither the original group nor the reformed group showed stability across days of work times, and this outcome is perhaps attributable to the competitive contingencies for individual compensation that were present throughout all work days.

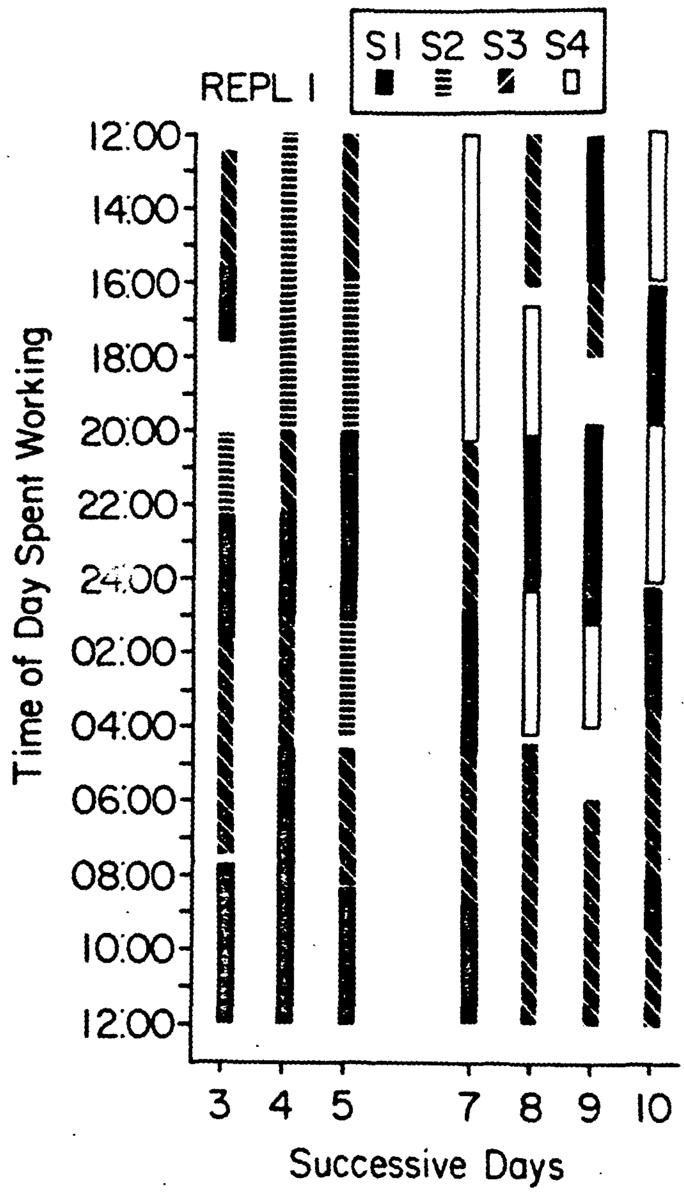

Figure 1. Time of day spent working on the individual Multiple Task Performance Battery for all subjects across successive days of the experiment (REPL 1) when access to work was permitted.

Figure 2 shows time of day spent sleeping for all subjects across successive days of the experiment. Comparatively stable sleep patterns were exhibited only by S2 who showed uninterrupted sleep episodes beginning between 2400 and 0500 hours across Days 1-5. During the same five-day period, Subjects 2 and 3 almost always showed erratic sleep episodes that differed across days in time of day of occurrence, frequency, and duration. Similar erratic patterns persisted during Days 6-10 when S2 was replaced by the novitiate (S4). Importantly, the novitiate showed the most consistent sleep periods across days, and S3 showed a clear reorientation in his sleep episodes that persisted throughout Days 7-10. These latter effects reflect the readjustments that were required by at least one original group member when the novitiate became a working participant during Days 7-10 of the experiment.

Figure 3 shows total urinary testosterone for all subjects across successive days of the experiment. With respect to the orginal group members, S2 showed testosterone values that were somewhat lower than the other two participants. Importantly, these comparatively lower values were evident during the first two baseline days of the experiment. When group members commenced working on Day 3, S2's values increased somewhat over baseline levels, but they continued to be below the values exhibited by the other two members across Days 3-5. Significantly, S2 was the mission member who did not compete successfully to remain within the experiment for ten days, and he was withdrawn at the conclusion of Day 5. Finally, across Days 7-10, testosterone levels progressively declined for S3 in relationship to his shift in work and sleep times. This latter effect

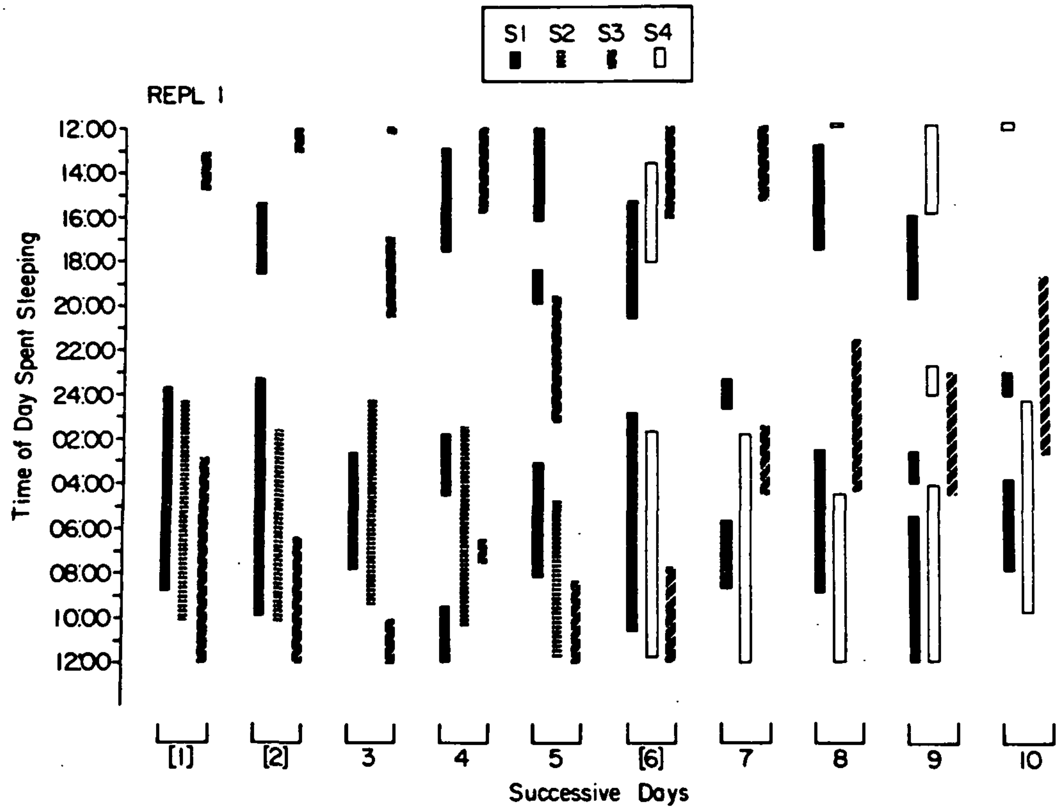

Figure 2. Time of day spent sleeping for all subjects across successive days of the experiment (REPL 1). Bracketed days [1], [2], and [6] were baseline "alone" days.

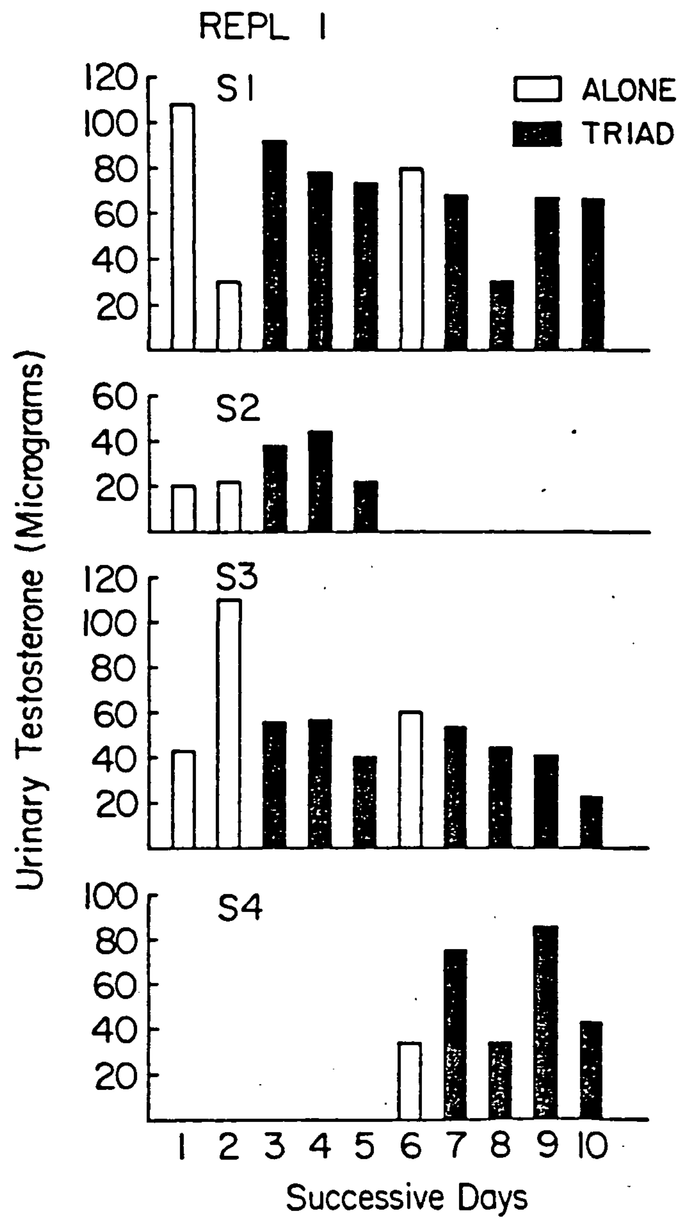

Figure 3. Total urinary testosterone for all subjects across successive days of the experiment (REPL 1).

confirms the outcomes observed in the introduction studies, and it demonstrates, by systematic replication, the generality of the behavioral-biological processes governing such effects.

The experimental design plan of the second replacement analysis (REPL 2) was similar to the first with two major differences. First, the novitiate group member was a female who had previously participated in an unrelated ten-day residential experiment, and she had almost 60 hours' practice on the MTPB. Second, to provide more days for competition to remain in the experiment and a longer history of sustained performance effectiveness by two group members prior to the novitiate's entrance, no initial baseline was programmed. The novitiate, then, entered the environment at the beginning of Day 6, which was a baseline day for all subjects, with more experience in the laboratory than the two other group members. Thus, the two ten-day participants were required to adjust to the replacement of an original group member by a person having extensive programmed environment experience.

Figure 4 presents time of day spent working on the MTPB for all subjects across successive days of the experiment when access to work was permitted. The novitiate participant is identified as "S4." Throughout Days 1-3, subjects alternated occupancy of the work station in an erratic fashion within and across days, with work periods lasting between 1 hour (*e.g.*, S1, Day 1) and 8 hours (*e.g.*, S1, Day 3). Subject 3 voluntarily withdrew from the experiment during Day 3, reasoning that his performance would not result in his participation beyond Day 5. Since the novitiate

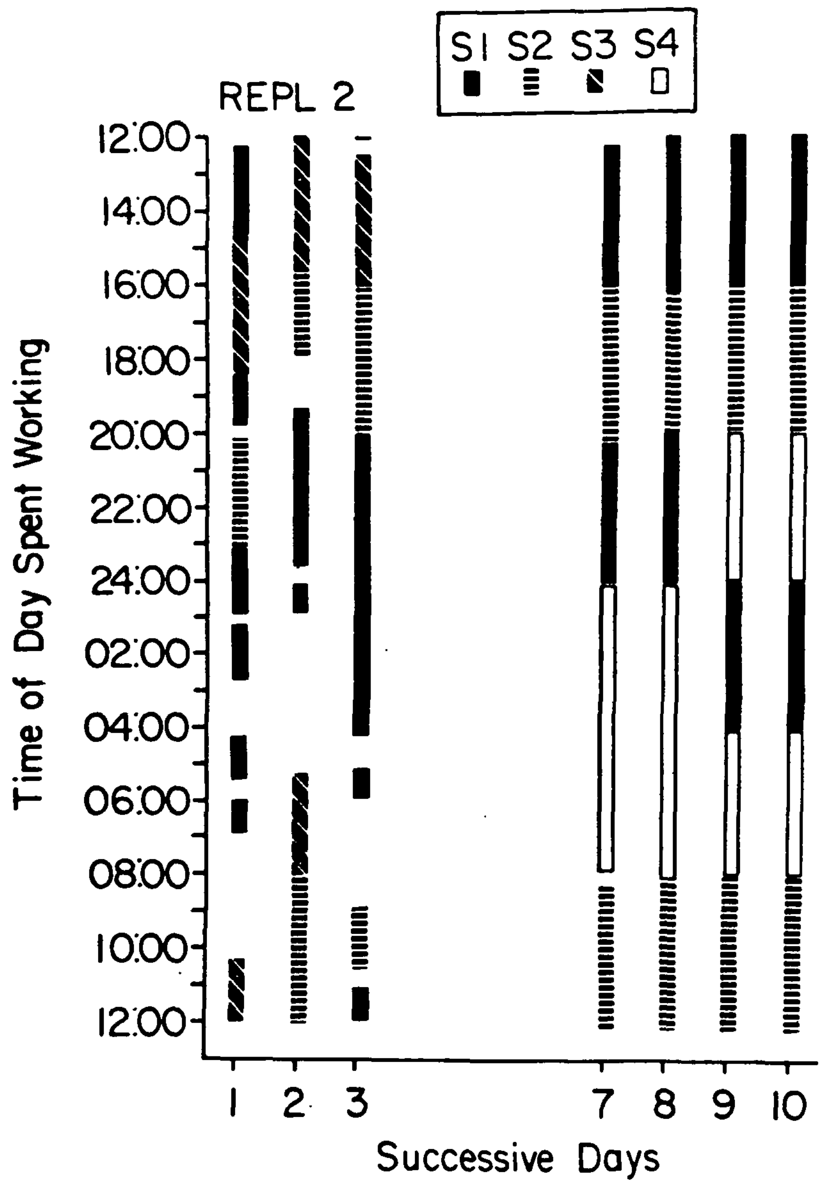

Figure 4. Time of day spent working on the individual Multiple Task Performance Battery for all subjects across successive days of the experiment (REPL 2) when access to work was permitted.

was not scheduled to appear until Day 6, a baseline day for all subjects, the two remaining subjects were programmed with baseline days on Days 4 and 5. This preserved the integrity of the experimental design plan in relationship to analyses of three-person working groups. In striking contrast to work times during Days 1-3, work times during Days 7-10 were orderly and precise. The pattern for Day 8 is identical to Day 7, and the pattern for Day 10 is identical to Day 9. Throughout Days 7-10, all subjects occupied the work station for eight hours each day.

These data show the impact of an experienced person, who exhibited assertiveness and leadership, on an established group whose members had previously competed successfully to remain within the experiment. Although the two-person group followed the suggestions, if not the directions, of the novitiate, S4 received negative interpersonal ratings on the Health Check questionnaires.

Figure 5 presents time of day spent sleeping for all subjects across successive days of the experiment. Although sleep times were perhaps not as erratic as those in the previous experiment, only S2 showed patterns that were somewhat consistent across all mission days. Additionally, the novitiate shifted her sleep pattern on Day 8, and she thereafter commenced sleep periods in the early hours (*e.g.*, 1200) of an experimental "day." Finally, the stable sleep patterns exhibited by all subjects on Days 9 and 10 corresponded to stable work periods also observed on those two final mission days.

In all previous investigations, the coordination required of mission

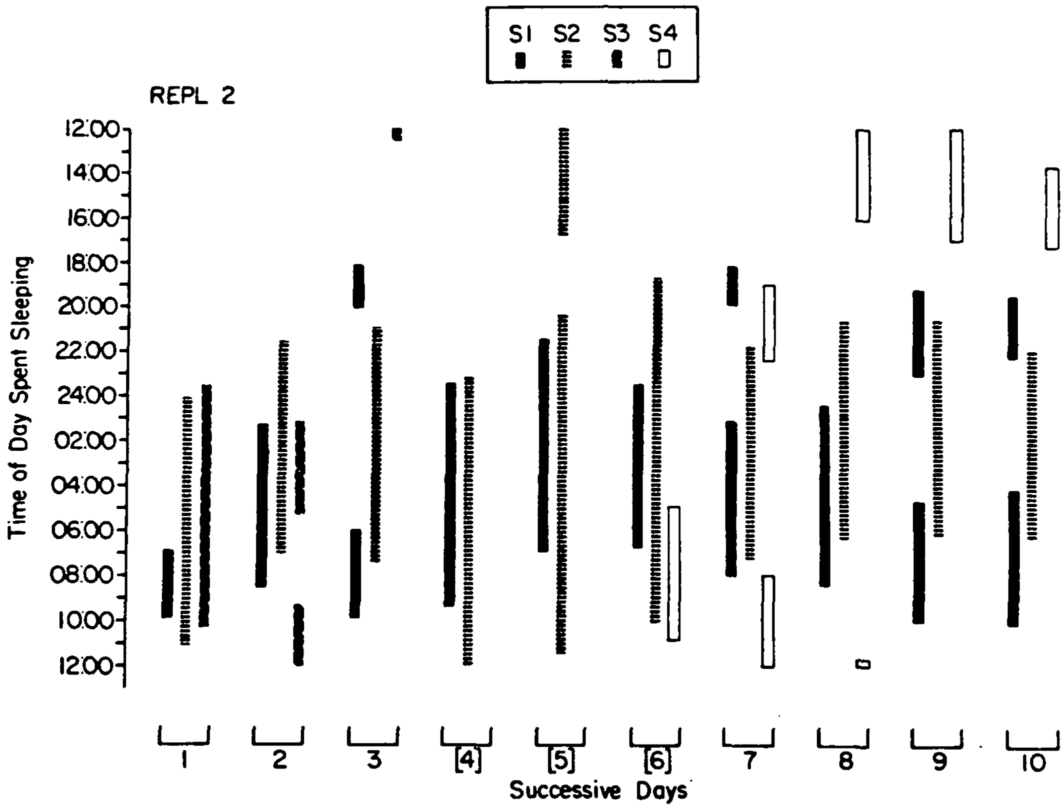

Figure 5. Time of day spent sleeping for all subjects across successive days of the experiment (REPL 2). Bracketed days [4], [5], and [6] were baseline "alone" days.

participants was reflected in the sequential use of the work station and in the program synchrony necessary for subjects to meet together in the recreation room. In the next replacement investigation (REPL 3), however, a team performance task was introduced into the research protocol that systematically replicated the preceding analyses with a task demanding far more stringent coordination requirements.

The team performance task is an expanded version of the single-operator MTPB that previously served as the project's principal performance assessment tool. The Team MTPB (TMTPB) involves three operator consoles, each console presenting the identical display of the five task components. The parameters of these tasks were modified to a difficulty level such that the concurrent inputs of three operators were required to avoid information overload and to produce maximum performance effectiveness per unit time. The "team" aspect of the task is reflected by the interlocking response demands associated with the probability monitoring subtask, and it is embedded within the context of the remaining four individually solvable subtasks. The team subtask requires the detection of a bias that was recurrently presented on any one or more of the four probability monitoring scales. Importantly, the operator inputs to the system to "correct" a bias requires each of the three operators to press the corresponding "correct" keyboard character within 0.6 sec of the first such keyboard entry. Although correction of a bias produces increments in accuracy points, a team's failure to detect a bias results in subtractions to accumulated points. The team task, then, requires (1) processing of symbolic information (i.e., the detection of a bias), (2) sharing information by communications among team members (*e.g.*, One operator may say "Bias on one. Ready...Go."), (3) coordination of a response (*i.e.*, three response inputs within 0.6 sec), and (4) sustained vigilance to avoid loss. This team task reflects the major performance dimensions considered to be crucial to developing methods for quantitative analyses of the interrelationships between individual and team performance effectiveness.

The ten-day experiment began with a three-man team whose members were new to the programmed environment and to the TMTPB. Participants had been acquainted with the *individual* MTPB during an orientation session, but acquisition of the TMTPB occurred for the first time on Day 1 of the experiment. For remuneration for participation, the team operated the TMTPB to a performance ceiling of 5000 accuracy points each day, requiring 6-9 hours of work to accomplish. The team members decided among themselves the manner of distributing the performance demands of the individual and team subtasks.

At the end of Day 5, one of the three original team members was withdrawn from the experiment. Initial team members began the study with the understanding that one participant would be withdrawn, but they were not given the decision rule by which that choice would be made. At the beginning of Day 6, then, a novitiate participant was introduced into the programmed environment. To accommodate this transition, the three participants followed the behavioral program in their private quarters on Day 6, but without access to the TMTPB, intercom communications, and social activities. On Day 7, the novitiate member joined the team as the replacement participant, and this newly formed team operated the TMTPB on Days 7-10.

Figure 6 presents time of day spent working by the team across successive days of the experiment. This figure shows that three or four work periods occurred each day, and they ranged in duration from two to five hours. Although the time of day associated with work periods differed across days, work was not generally observed between 2400 and 0800 hours of a day. Finally, the pattern of work that the initial team adopted was also observed during the final four days of the study with the reformed team.

Figure 7 presents time of day spent sleeping for all subjects across successive days of the experiment. The novitiate participant is identified as "S4." Although the behavioral program was not oriented to time markers, sleep periods were generally stable across successive days for both original and reformed teams. When drift in sleep onset time occurred across days, all members of a team drifted in concert with each other.

The dynamics of the components of the individual and team subtasks differed. Figure 8 shows, for example, points earned on the individual subtasks of the TMTPB across successive work periods. This figure graphically shows smooth initial acquisition (Segment 1) and reacquisition (Segment 2) trends on the individually solvable subtasks. Additionally, it shows that the reformed team exhibited degraded performance during the first two work periods of Segment 2 and that performance reacquisition was more rapid than was acquisition by the original team. Performance on the individual subtasks was degraded despite the presence of two team members

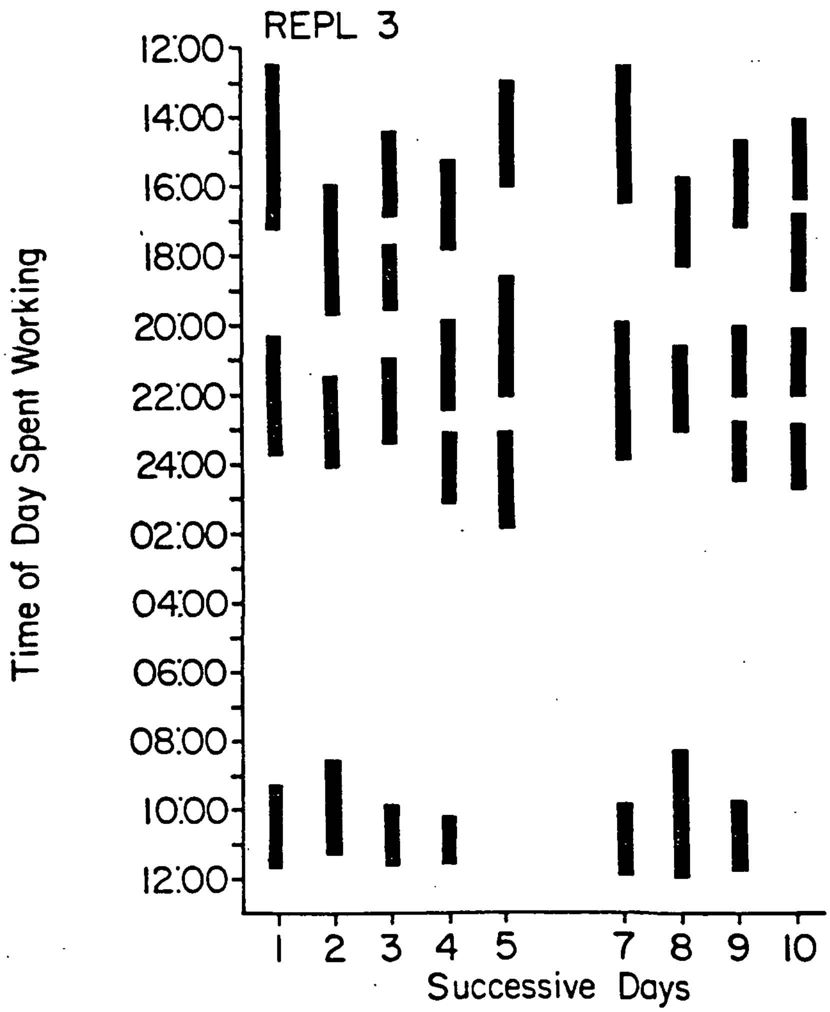

Figure 6. Time of day spent working on the Team Multiple Task Performance Battery across successive days of the experiment (REPL 3).

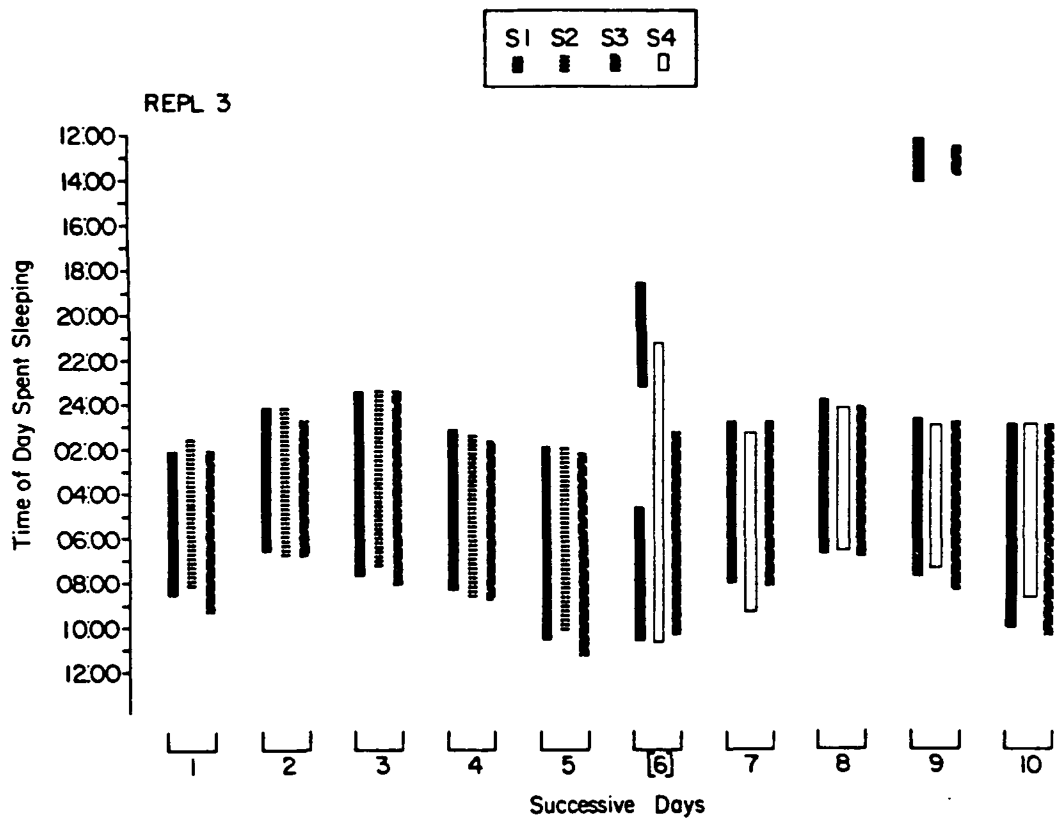

Figure 7. Time of day spent sleeping for all subjects across successive days of the experiment (REPL 3). Bracketed day [6] was a baseline "alone" day.

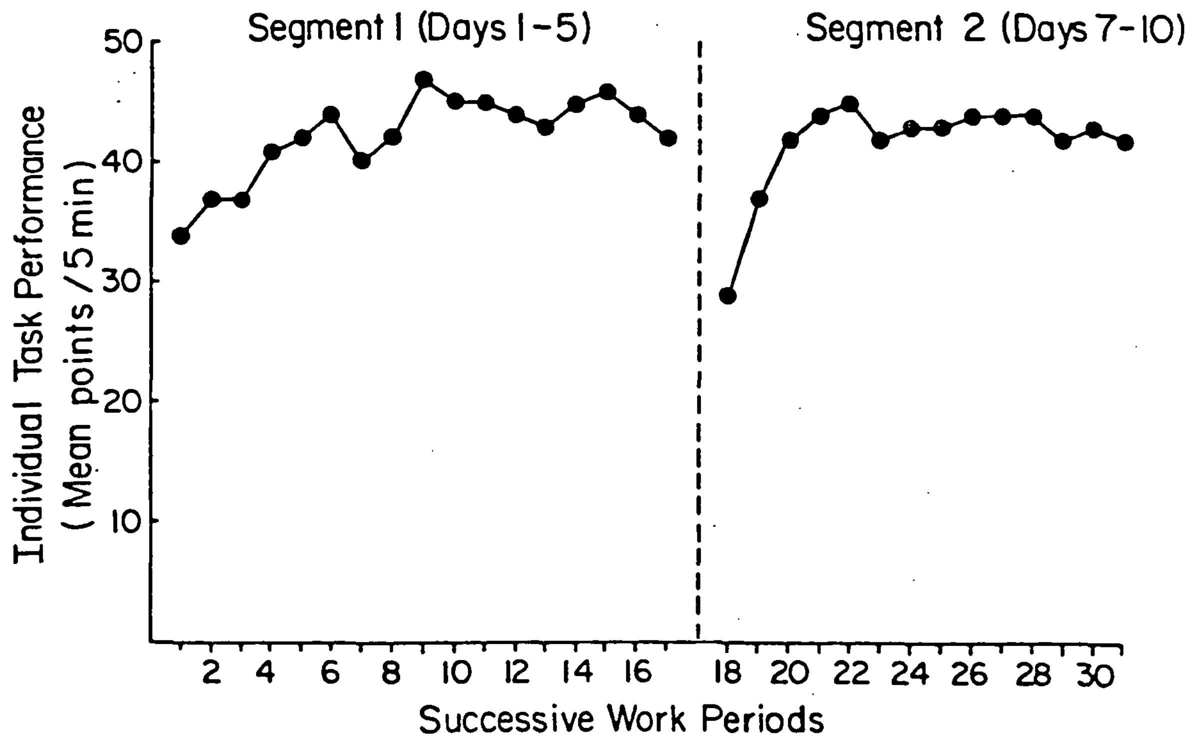

Figure 8. Points earned on the four individual subtasks of the Team Multiple Task Performance Battery across successive work periods.

who had a combined total of almost eighty hours' practice on the TMTPB. That such performance degradation was not associated with social disruption was indicated by the absence of negative ratings toward the novitiate as determined from recurrent Health Check assessments.

Figure 9 shows points earned on the team subtask of the TMTPB across successive work periods. In contrast to individual task performance, performance effectiveness on the team task was erratic, even though a trend toward improved team performance is graphically apparent for initial (Segment 1) and reformed (Segment 2) teams.

These observations suggest that improvement in combined individual and team performance effectiveness over successive work periods was attributable, in large part, to improvement on the contextual individual subtasks. Additionally, preliminary analysis shows that improvement on the team subtask for the orginal team (Segment 1) was attributable to a progressive "sharpening" of the discrimination in the manner of fewer false alarms over successive work periods. Such was not the case, however, for the reformed team (Segment 2). During Days 7-10, whatever improvement there was on the team subtask was attributable to fewer missed biases and not to fewer false alarms. Thus, a clear shift occurred in the operation of the team subtask between Segments 1 and 2, despite the overall trend toward improved performance across both segments.

The performance shift observed on the team subtask between Segments 1 and 2 suggests the involvement of a more complex process of acquisition and reacquisition than repeated practice. Such a process might involve

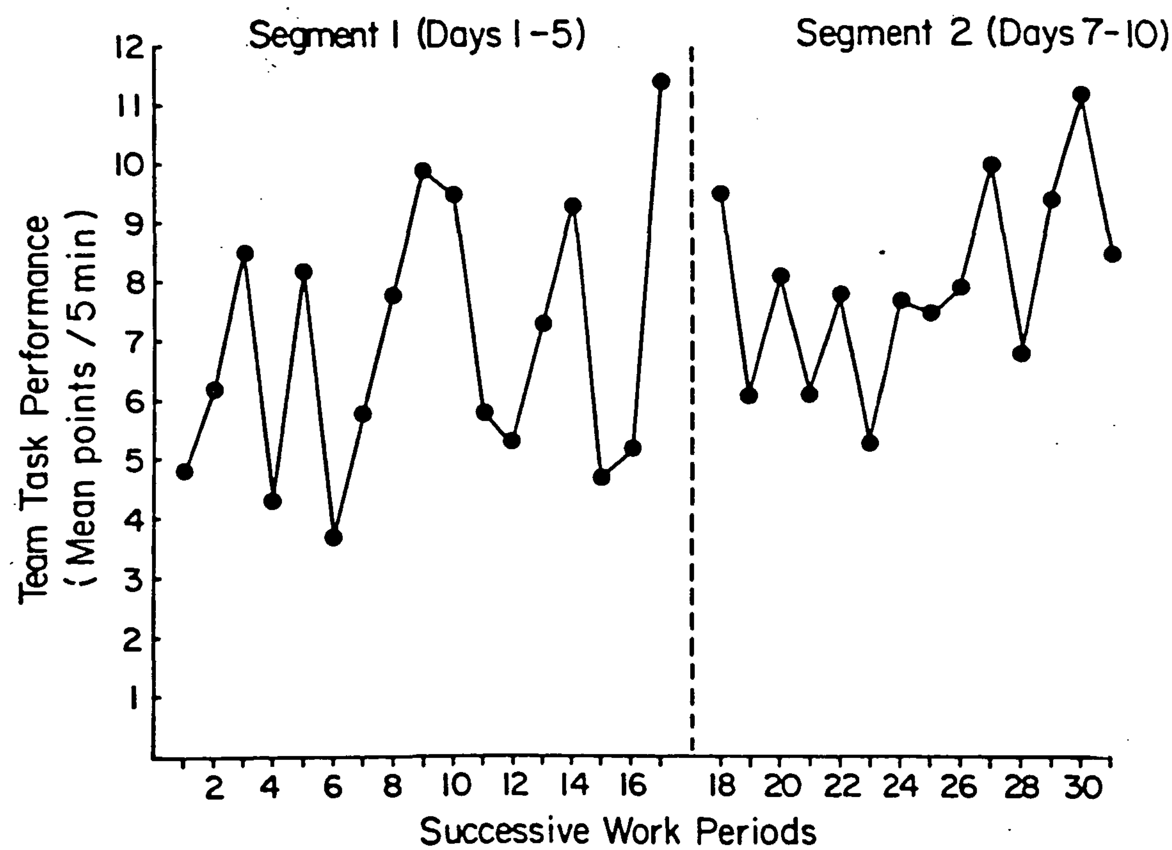

Figure 9. Points earned on the team subtask of the Team Multiple Task Performance Battery across successive work periods.

"solution strategy rehearsals" among team members for responsibility in operating the several subtasks. For example, when the novitiate joined the team, the two original team members likely assumed rotational responsibility for monitoring the team subtask to avoid potential losses while the novitiate mastered the discrimination. Finally, the prominent involvement of such rehearsals and rotations is further indicated by the fact that progressive improvement in overall performance effectiveness was attributable, for the most part, to improvement between successive work periods rather than to improvement within work periods.

Much more needs to be learned about those strategies and rotations and their dynamic interplay with individual and team performance effectiveness. Against the background of the introduction analyses that showed an established team's resistance to accepting a novitiate's work, the present study shows that a novitiate's lack of skill on a task can perhaps be masked by experienced team members who are unwilling to tolerate even a temporary degradation in overall team performance effectiveness. The penalty of such a strategy is to be understood in terms of the constraints on redundancy of skills that could result in even more drastically degraded performances under conditions of further replacements of the original team members. By developing quantitative (i.e., computer assisted) approaches to assessing the moment-to-moment performances of team members, the relative contributions of individual member performance to the terminal steady-state of the system can be characterized. At the very least, such a characterization would suggest intervention guidelines or pre-training schedules that would ensure the most effective balance between individual and team performance effectiveness and subtask proficiency under the various conditions of membership turnover.

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