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A SCATTER PLOT FOR IDENTIFYING STIMULUS CONTROL OF PROBLEM BEHAVIOR

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Line graphs that average response frequency over long periods obscure the major rate changes that indicate sources of behavioral control. A scatter plot can make patterns of responding identifiable and, in turn, suggest environmental features that occasion undesirable behavior. Use of scatter diagrams is illustrated in three cases.

DESCRIPTORS: data analysis, stimulus control, antecedents, self-injury, aggression

It is customary to try to identify the stimuli that set the occasion for troublesome responses (Carr, Newsom, & Binkoff, 1976; Favell & Greene, 1981; Gaylord-Ross, 1980; Iwata, Dorsey, Slifer, Bauman, & Richman, 1982; Patterson, 1974). Attempts to isolate such stimuli, however, often fail. The array of possible controlling stimuli in any applied setting may be too broad to test. Research has shown that the relevant environmental features may be neither simple nor intuitively obvious (Rincover & Koegel, 1975). Thus, difficulties discovering functional controlling relations can render unworkable the elegant strategy of eliminating problem behavior by altering the stimuli that control it.

A scatter plot can help in identifying patterns of responding in natural settings. Ferster and Skinner (1957) pointed out that overall response rates were usually made up of ". . . short bursts of responding at a constant local rate alternating with periods of no responding" (p. 27). Severe problem behavior typically conforms to this pattern. It virtually never occurs at a steady rate throughout the waking hours (Gaylord-Ross, Weeks, & Lipner, 1980; Plummer, Baer, & LeBlanc, 1977). Instead, there are periods of high rate responding and other periods of no responding in the course of each day. The usual method of plotting response frequency in a line graph, however, reveals only the average rate, not the pattern of responding. A line graph with days or weeks on the ordinate averages responding over time so that important changes in rate within each day are obscured. For this reason, line graphs usually do not suggest probable sources of environmental control. Severe problem behavior may assume only two practically important rate values, zero and unacceptable. A scatter plot can display periods during which problem responding virtually never occurs or occurs with near certainty.

Dramatic, infrequent stimulus-response relations are often easily identified. A child may engage in disruptive behavior when left alone for a lengthy period or if a favorite toy is misplaced. If the problem behavior is rare and the conditions that control it are also rare, the obvious correspondence suggests a valid functional relation. The need for more formal pattern analysis like a scatter plot arises when the target behavior is frequent, and informal observations do not suggest a reliable correspondence with anything in particular.

This data analysis approach was developed in the context of residential programs for autistic adolescents. Our examples are drawn from those environments. The approach could, however, be readily adapted to any setting where sufficient data

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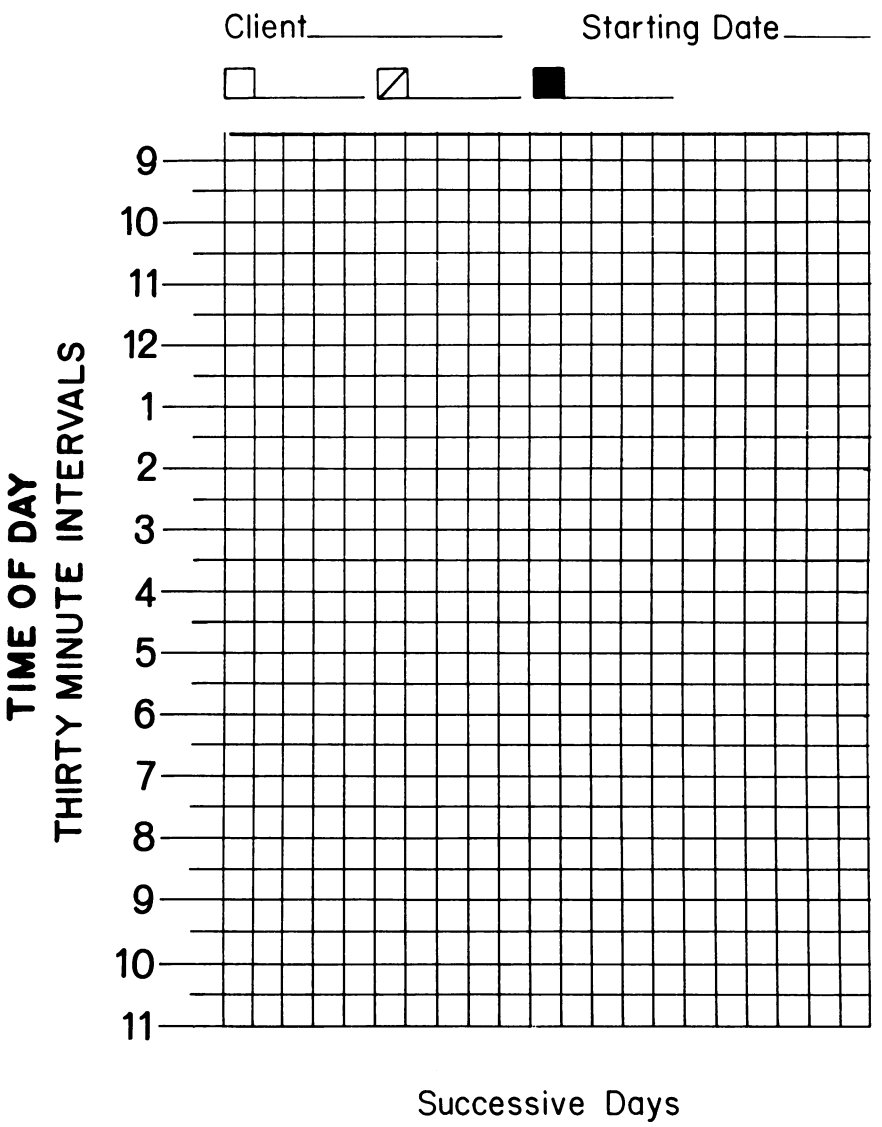

Figure 1. Scatter plot grid with a key at the top to indicate response frequencies corresponding to filled, slashed, and open boxes. Each location on the grid identifies a unique time interval on a given day.

are available including home-based, self-management, community, industrial, and educational programs. The data necessary for a scatter plot are those typically collected in applied settings: frequency counts in half-hour or shorter intervals. Minimal training is required to generate this visual display. The simplicity of this vehicle enables the observer to record directly on a scatter chart or transfer observed frequencies to it without calculation. The visual patterns that result lend themselves to easy interpretation as the following examples show.

GENERAL PROCEDURE

The first step is to design a grid like that in Figure 1. Vertically, the grid segments time of day into hours, half hours, quarter hours, or any time unit appropriate to the duration of elements of the client's schedule. Horizontal segments of the grid

represent successive days. When data are plotted, a blank cell is used to represent a 0 rate. Filled cells are used to indicate that the problem behavior occurred during that interval. In some cases it is useful to break the occurrence category into high and low rates. The lower frequency can be recorded as a slash or an outlined cell. We have found that more than three categories can result in charts that are difficult to interpret.

The frequency differential sufficient to produce a cell change must reflect the character of the behavior problem under consideration. For many serious behavior problems the only acceptable rate is 0. A low rate category can have practical significance even when the eventual target is complete elimination of the behavior. The occurrence of a lower than usual frequency may constitute an important approximation and suggest the course of program development when there are few or no 0 intervals in the baseline. As with all visual data presentations, plotting parameters must be selected so as to ensure that the display is both accurate and easily interpreted.

As the scatter chart is filled with observations, each unit of time contains a designation indicating whether the behavior occurred at a high, low or 0 rate. An initial evaluation of variables associated with high, low, and 0 rates is then obtained by visual inspection of the data array. A pattern, should one exist, can emerge as soon as several days are plotted. When observations are recorded for 7 successive days, the atypical character of the weekend can add further insights as in Case 1, below.

Problem behavior may be highly correlated with a time of day, the presence or absence of certain people, a social setting, a class of activities, a contingency of reinforcement, a physical environment, and combinations of these and other variables. Very likely, several probable sources of control are confounded. As the following case examples show, it may not be necessary to isolate the specific controlling variable(s) to eliminate the problem behavior. The three cases presented below illustrate some uses of scatter plots. In each case the scatter diagram facilitated identification of a relationship between problem behavior and one or more environmental features. Altering the client's schedule, activities, setting, or instructors reduced or eliminated the target response(s).

The three adolescents in these illustrations had all been diagnosed as autistic or autistic-like (Rutter, 1978) and moderately to severely retarded. Etiologies were unknown, but their current health was excellent. Examination by a physician revealed no pain sources, seizure activity, or other reason to suspect a physiological basis for self-injurious or assaultive behavior.

Interobserver Agreement

The data reported here were collected by program staff in the course of their daily responsibilities. Reliability observations were recorded by other program staff and us. The extended period of time (12 or more hours a day) covered by these scatter plots could present a special problem in estimating interobserver agreement. Fortunately, the responses to be tracked were few in number, grossly deviant, and readily identifiable. Reliability of response recording was evaluated in all three cases both during baseline and subsequent to intervention. Interventions resulted in long periods with no occurrence of the target behavior. Interobserver agreement was calculated using the following formula: agreements/agreements + disagreements × 100. An interval was scored as an agreement if both observers recorded the target behavior as having occurred at the same rate category (0, low, or high). In Cases 1 and 3, interobserver agreement was evaluated for half-hour intervals; but in Case 2 reliability assessments were based on 5 minute intervals. Reliability checks resulted in 100% agreement between observers in all instances.

Case Illustration 1

This case illustrates the use of a scatter diagram as a tool for discovering aspects of a therapeutic program that provoked problem behavior and those that made it unlikely. The target behavior was assaulting people. Joan was a 14-year-old girl who

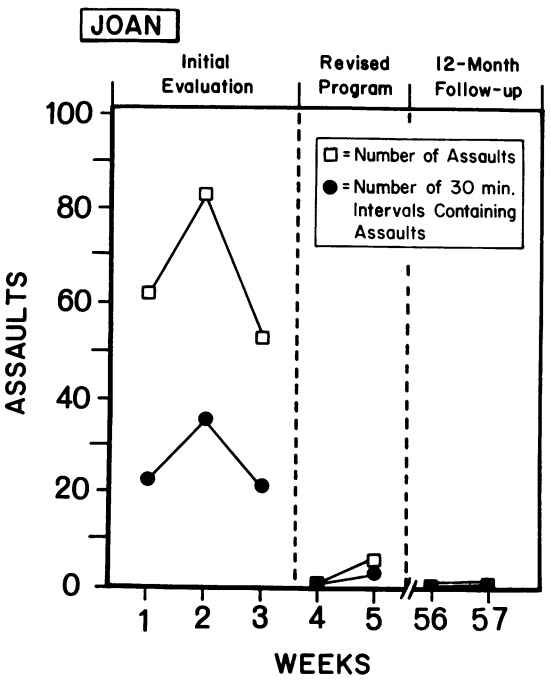

Figure 2. Conventional plot of Joan's assaults that includes both raw frequency of incidents, and number of 30-minute intervals containing an incident. A total of 182 intervals per week were recorded.

had a history of serious aggression, first noted when she was only 4 years old. Her assaults had injured staff and peers. Her outbursts were disruptive and necessitated her removal from educational activities. This young woman lived in a residential school for autistic adolescents where she had been placed 3 years earlier when her behavior at home became uncontrollable. Joan was functionally mute, and she had a Leiter mental age estimate of 5 years.

A scatter plot was used to identify environmental features associated with assaults which were defined as two hits, kicks, or head butts directed toward staff or peers within 10 seconds or a single hit to the face or object thrown at someone. Data were collected throughout Joan's waking hours, both weekdays and weekends. A time-out procedure was in effect for assaults throughout the period reported. It proved ineffective but was continued to protect other students.

The total number of incidents of violence ranged from 53 to 82 per week during the initial 3 weeks of observation. Assaults occurred in 21 to 36 of the 182 half-hour intervals. Treatment team records indicated that assaults had been in this same range for months. Prior to the development of the scatter plot, a variety of interventions had failed to reduce the rate of assaults. A line graph of Joan's data during baseline is on the left side of Figure 2. The raw number of episodes and number of intervals in which episodes occurred are well correlated, but neither suggests controlling variables.

Figure 3 presents Joan's data in a scatter plot. The pattern of occurrence has several revealing features. The grid shows that assaults were most frequent between 1:00 and 4:00, Monday through Thursday. Equally important is the pattern of periods when assaults did not occur. Assaults were least likely on weekdays in the early morning, at lunchtime, and after 4:00 p.m. Assaults were rare all day Friday, Saturday, and Sunday.

Incidents were most likely during the time Joan attended group prevocational and community living classes, 1:00–4:00 on weekdays. On Friday afternoons, her schedule was different; it included field trips or swimming. Joan's weekday mornings were spent in one-to-one instruction, suggesting that demands and training alone did not provoke assaults. Uneventful group activities in the community and at the gym suggested that simply being in a group was not the provocation.

Joan's activity schedule was revised on the basis of the scatter pattern. Conditions associated with filled cells were replaced with conditions associated with empty cells. The first hour in the morning, lunch, supper, evenings, and weekends were unchanged because they were unlikely times for assaults. Joan continued to receive tutorial instruction in the morning. Afternoon requirements for group participation were eliminated. A new afternoon schedule was arranged to approximate the staff interactions that Joan had on weekends and during the evening. Staff aides were assigned to work with Joan between 12:30 and 4:30 p.m. They engaged her in informal activities which included listening to stories, trying on cosmetics, and playing with stickers. Activities were changed every 15 minutes. Each interaction continued until Joan

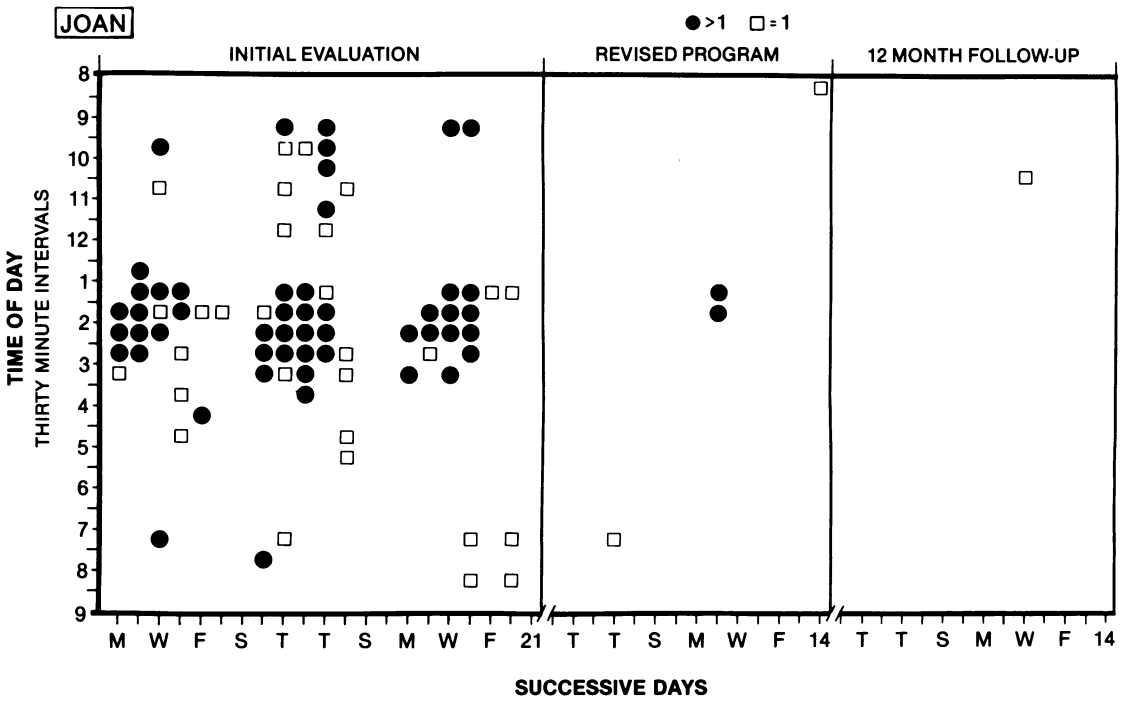

Figure 3. Scatter plot of Joan's assaults. Filled circles indicate 30-minute intervals during which more than one assault occurred. Open boxes represent intervals with only one assault.

was inattentive for 15 seconds or motioned the teacher away.

When the revised schedule was initiated, assaults decreased immediately as indicated in Figures 2 and 3. At first, Joan's afternoon time was spent outside the classroom area in the hallway or sitting on the stairs. In the first week, interactions were brief and occupied only 100 of a possible 960 minutes. Over 30 days, they increased to more than 400 minutes per week.

Elements of Joan's original program, previously associated with assaults, were then gradually reintroduced into her afternoon schedule. In the fifth week, Joan was scheduled to be present in a classroom for 15 minutes of each hour. During the third and fourth months, demands were increased, and Joan engaged in classroom activities in 15-minute blocks with each of the several teachers on her team. The duration of teaching sessions was then increased in 2-minute increments based on her successful performance with all of her teachers. By the fifth month, she was spending 30 minutes with each teacher and had been reintroduced for brief periods into her original group instruction setting. The duration of this activity was also increased in 2-minute increments based on her performance. There was no increase in assaultive behavior throughout.

After 12 months, Joan was participating in group classes during 3 of the 4 hours between 1:00 and 5:00 p.m. and in structured individual activities during the fourth hour. Figures 2 and 3 show that only one assault occurred during a 14-day period 1 year after baseline. During the follow-up period, data on single hits and any minor assaultive acts in which Joan had previously engaged (e.g., pinching) were also recorded. One single hit occurred during the 14-day period and no other topographies of assaultive behavior were observed.

The scatter plot identified a pattern in Joan's aggression. The behavior was prevalent at certain times of day on certain days of the week. These times were correlated with one element of Joan's program. Eliminating that element drastically re-

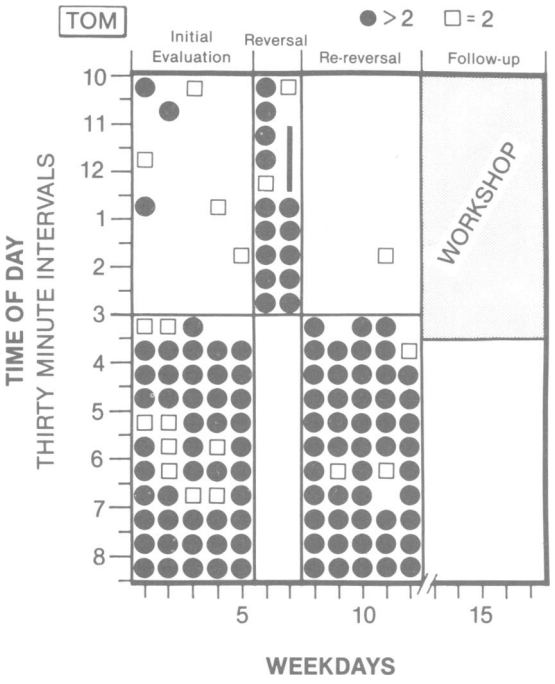

Figure 4. Scatter plot of Tom's self-hits. Filled circles indicate intervals during which three or more hits occurred. Open squares indicate intervals during which two hits occurred. On the second day of the reversal, Tom was out of the house at a physician's appointment between 11:00 and 12:30.

duced assaults. Joan's original training program was then successfully reintroduced by gradual approximations.

Case Illustration 2

In this case a scatter diagram was used to isolate a confounded variable that controlled self-injurious responding. Tom was 23 years old and lived with other autistic adults in a community residence. He had been hospitalized with recurrent septisemia resulting from self-inflicted face and hand wounds. His irreparable detached retina was thought to be secondary to head hitting. Tom wore a helmet and face guard to prevent further injury.

Self-abuse was defined as a blow to any part of the body or striking any part of the body against a solid object. A small quantity of snack food was given to Tom following each 5-minute interval in which self-abuse did not occur (DRO 5′) throughout the period covered by the scatter plot. Tom was also required to place his hands behind his back for approximately 10 seconds following each self-hit.

Two aides worked with Tom on a one-to-one basis. The first person worked from 9:00 a.m. to 3:00 p.m., the second from 3:00 p.m. to 9:00 p.m. Tom's activities included self-care, housekeeping, watching television, riding an exercycle, and table-top prevocational tasks. The first and second shift each had a unique array of activities. Each activity was selected based on Tom's functional level to make success likely and to minimize the probability of provoking self-abuse.

Data were gathered from 10:00 a.m. to 8:30 p.m. and recorded on a scatter chart (Figure 4). Filled circles indicated that Tom struck himself three or more times during the 30-minute interval. Two hits occurred in each interval with an open square. Blank areas indicated the absence of abusive behavior or one isolated hit. Figure 4 shows that self-abuse occurred principally during the late afternoon and evening. Activities, schedule, and staff changed at 3:00 p.m. In addition, Tom's peers returned from school at approximately that time. Increased self-hitting corresponded to an increase in the number of peers present, the staff person assigned, and the afternoon activities. All three elements changed at about the time Tom's self-abuse escalated each day.

One element was altered to determine if it controlled the rate of self-hitting. The morning aide worked during the late afternoon and the afternoon aide worked during the morning. Other suspected elements were held constant. Activities were carried out at the usual times and Tom's peers returned home on schedule. Figure 4 shows that rescheduling the aides displaced self-abuse from late afternoon and evening to morning and early afternoon. After 2 days, the aides resumed their original schedule and Tom's self-hitting again occurred predominantly in the late afternoon and early evening. No clear explanation why one person was so successful and one so unsuccessful was evident. The difference was something subtle which neither they nor we could identify. The group home managers subsequently solved the problem when

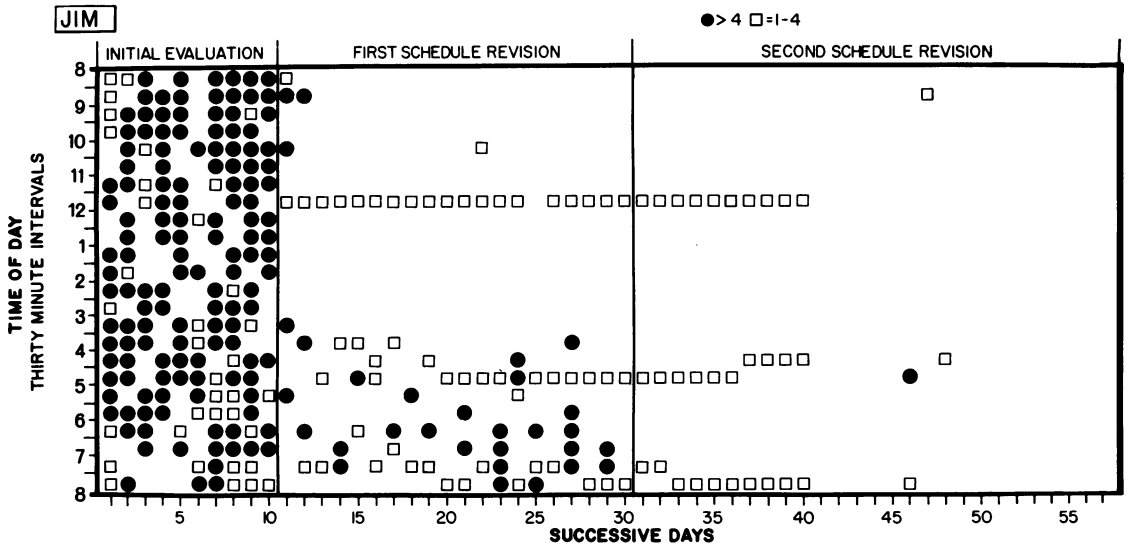

Figure 5. Scatter plot of Jim's self-hits. Filled circles indicate intervals during which five or more hits occurred. Open squares indicate intervals during which one to four hits occurred. Jim slapped his face once ritualistically prior to lunch, supper, and evening snack. These three daily responses account for the long horizontal patterns of open squares. The responses were recorded but otherwise ignored. They subsequently dropped out, but not as the result of any specific manipulation.

Tom was accepted in a well-run sheltered workshop. With mornings and early afternoon spent at the workshop, the aide associated with low rates of self-hitting was rescheduled to work with Tom in the late afternoon and evening.

Case Illustration 3

This case demonstrates that uninterpretable scatter plot data may reflect an unstable environment. Jim was a self-abusive student at a residential school for autistic adolescents. He hit his face with his closed fist and slammed his head into walls or furniture from 50 to 1,600 times a day. To prevent injury, he wore a protective helmet and mask. He had a staff person in close proximity around the clock and participated in few activities with his peers. Jim was 15 years old and his estimated MA (PPVT) was 3 years, 2 months. He was mute, except for a few words uttered only in a language training context. Jim had been placed in a residential program at age 9 when his behavior at home had become unmanageable.

Self-abuse was defined as any blow to his head with his hand or bringing his head into contact with a solid object. During the initial data collection period, Jim engaged in a loose schedule of activities that staff thought to be reinforcing (e.g., making hot chocolate, watching TV, taking short walks on the school grounds, listening to music, and making popcorn). During the first 5 days in Figure 5, self-abuse produced a 5-minute period during which Jim was required to mop vigorously, an activity that he appeared to dislike. During the next 5 days in Figure 5, each self-hit produced a water mist from a spray bottle directed toward Jim's face, another consequence that he appeared to dislike. The low-demand/high-reinforcement density schedule combined with mild aversive consequences did not reduce daily response frequency.

The scatter plot in Figure 5 shows 30-minute periods with five or more self-hits as filled circles and those with one to four hits as open squares. There are many intervals during which Jim hit himself interspersed with periods of up to several hours free of self-abuse. Although many of Jim's waking hours were free of self-abuse, no stable pattern emerged. What Jim did, when, where, and with whom were not stable either. His program included offering him several choices on a menu board every 30 minutes and asking him to indicate

which he preferred next. Each activity was continued for 30 minutes or until Jim would no longer engage in the current one. He was so difficult to supervise that staff members rotated responsibility for his supervision every few hours. In essence, the only pattern that could appear would indicate that time of day alone influenced self-abuse.

A new fixed schedule of activities was designed. Jim's team sorted setting-activity combinations into five categories. A "5" was something virtually guaranteed to provoke self-hitting. A "1" was most likely to produce acceptable behavior. The new schedule included necessary activities such as dressing, eating, toothbrushing, and bathing. All other times were filled with activity-setting combinations rated "1," "2," or "3." Figure 5 shows that the new schedule alone reduced the number of severe self-hitting intervals.

Residual problem behavior formed a pattern. It occurred almost exclusively in the evening. Staff rotated shifts so the frequency of responding was not tied to people. Jim's self-hitting in the evening appeared to be related to some aspect of his evening activity schedule. His evening program was revised to closely resemble his morning program, which was now virtually problem free. This involved altering the sequence and duration of activities as well as their location. With this second schedule revision, the first of many abuse-free days occurred (Fig. 5, Day 42).

DISCUSSION

Stimulus control of behavior is most often addressed as a *problem*. Desirable behavior taught in one context often fails to generalize to another (Marholin & Touchette, 1979; Stokes & Baer, 1977). This phenomenon is so ubiquitous that it is assumed by widely used multiple baseline research designs (Barlow & Hersen, 1984, p. 210; Kazdin, 1982, p. 134). Undesirable behavior is functionally identical to desirable behavior. It too can be probable under one set of circumstances and unlikely in others. Patterns of behavior evident on a scatter plot can suggest stimuli that control problem behavior. It may then be possible to reduce undesirable responding by eliminating stimuli that control high rates or by putting in place stimuli that control low rates of problem behavior (Jenkins, 1965; Rilling, 1977; Terrace, 1966b).

Stimulus conditions in school, home, or work environments vary with the time of day and day of the week. Each change in location, activity, contingency of reinforcement, or social setting creates an opportunity to evaluate the impact of these variables. When a change in setting systematically corresponds to a change in behavior, this suggests a controlling relation. Unfortunately, the process of identifying controlling relations *precisely* can be time consuming in both laboratory (Ray & Sidman, 1970; Terrace, 1966b) and field (Charlop, Schreibman, Mason, & Vesey, 1981; Patterson, 1974; Schroeder, Rojahn, & Mulick, 1978). Precise identification of controlling relations may not be necessary. An alternative approach is to identify broadly defined control and to pursue a functional analysis in detail only if it proves essential to achieve the desired end.

A scatter diagram has inherently low resolution as a rate reporting device. Each cell can assume only two or three values corresponding to gross changes in rate within an observation interval. Patterns of presence and absence may, however, be sufficient to suggest control exerted by setting events. Shifts in rate of responding from high to low or low to high, corresponding to a change in setting, do not just suggest stimulus control, they define it (Terrace, 1966a). An issue for extensive future investigation is the level of refinement of that definition necessary to achieve applied goals.

Controlling relations in the cases above were at best vaguely specified. It appears, however, that identifying functional control can be of practical value even though the controlling stimuli are not precisely defined. The three cases suggest that it is sometimes possible to eliminate problem behavior without understanding the variables that control it in detail. More exact analyses would definitely require an allocation of resources difficult to justify in most applied settings.

The data reported here serve only to illustrate the assessment method. They demonstrate how the

scatter plot can be used as an assessment tool. Confounds and weak experimental evidence severely restrict any conclusions that might be drawn concerning the interventions that were implemented. This plotting method, however, does offer insights into patterns of responding not readily available from graphs of daily or weekly frequency. Questions remain to be resolved concerning the construction and use of scatter diagrams. It is not yet clear how best to select the values for filled and empty cells. Neither is it clear whether these diagrams are useful beyond an initial assessment. The production of this form of visual display may pay valuable dividends, and it makes minimal demands on staff time or skill. Many behavior analysts already record response frequency in 5-, 15-, or 30-minute blocks. For them, developing a scatter diagram simply means looking at available data in a different format.

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