Behavior Analysis

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400. Trybus, R. J., and Lacks, P. B.: MENTAL RETARDATION

INTRODUCTION

New opportunities for behavioral competence are becoming increasingly available to people once considered untrainable and consigned to private attics, church basements or the restrictive wards of state institutions. Behavior-analytic methods are producing dramatic changes in such people regardless of the etiology, severity or chronicity of their handicap, or their age, psychometric classification, socioeconomic status and other factors once thought to determine their "trainability."

This chapter describes the ingredients of behavior analysis. It sketches some highlights of the experimental origins of current applications, and it presents some of the refinements that most directly affect the habilitation of severely retarded behavior. Finally, it outlines some of the important results and suggests some directions for future development.

Neither a how-to manual nor a comprehensive review of the literature, its purpose is to provide some perspective for those who wish to become familiar with the current range of behavior-analytic endeavors on behalf of severely handicapped people. Those who seek more detailed procedural information will find ample references for further study.

WHAT IS BEHAVIOR ANALYSIS?

Behavior analysis is a methodology that identifies and manipulates environmental conditions that are actively affecting a person's behavior. Its
variables are behavioral events and environmental events. Because they are observable and measurable, their interactive effects can be studied with the objective, systematic methods of scientific inquiry.117:134,205,221,349,404

Although a person's activities within an environment are continuous, dynamic and often complex, the basic ingredients can be described in terms of physical (operational) and functional components. The operationally defined components of ongoing behavior in a given environment are called antecedent events, movement cycles, arrangements and subsequent events.239 If directly measured behavioral changes reveal a functional relationship, or interaction, among these components, their more familiar designations apply: stimulus, response, contingency and consequence. The distinction is critical in analyses of retarded behavior, which often fails to show expected, or "normal," interactions with the recognized events of a "normal" environment.

Movement Cycles: Potential Responses

Behavior analysis requires that its subject matter be measured. Therefore it focuses on what a person does—acts or sequences of acts described precisely enough for independent observers to agree on their occurrences. To account for the dynamics of behavior-environment interaction, behavior analysis further requires that acts be repeatable movement cycles with discernible beginnings and ends.126 Each movement cycle consists of an act with respect to an object, e.g., raising one's arm,137 rocking one's body,188-190 banging one's head,260 assembling bicycle brakes,161

Almost all persons with retarded behavior engage in various movements, many of which can be converted into functional responses that produce something from the immediate environment. If a movement cycle increases in frequency when repeatedly followed by an appropriate environmental event, it becomes a functional response. Movement cycles that fail to change the environment may drop out of the behaver's repertoire. Those that produce positive environmental events for the behaver will be accelerated even though the behaver may be objectionable to others. The variety of behaviors in a person's repertoire may depend largely on whether the environment has regularly reacted in a way that makes those behaviors functional for the behaver. Analyses of retarded behavior have shown that objectionable movement cycles often become functional responses while more desirable movement cycles do not develop into functional responses because they do not systematically produce environmental reactions.56,121,122

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Arrangements of Subsequent Events: Potential Contingencies

The environment may not react to every occurrence of a behavior. Most behaviors produce only intermittent environmental change. In the context of behavior-environment interactions, an arrangement describes what the environment requires of the behavior before it reacts. An arrangement is, then, a behavior-dependent schedule of environmental reaction.

Research has shown repeatedly that an arrangement providing a demonstrated positive consequence (reinforcer) every time a response occurs is most effective for generating a new behavior. However, once a behavior has been taught, it is more likely to be sustained in the behaver’s repertoire if the arrangement is made more intermittent — scheduling that sustains most “normal” behavior. For example, a positive consequence may be delivered after a fixed or varying number of responses has occurred, or it may be made available at regular or varying time intervals if at least one response has occurred. Each type of arrangement produces its own distinctive pattern of sustained responding.

If an already functional response varies in frequency with different arrangements of an already functional consequence, the arrangements are functioning as contingencies. Like other manipulable components of behavior-environment interactions, the contingent relationship between a particular behavior and its consequences may be deliberately arranged in an effort to change behavior. While the predominantly intermittent schedules of the “normal” environment may function as adequate contingencies for “normal” behavior development, such arrangements may not be functional contingencies for developing more competent beh-

Repetitive use of fixed or variable schedules produces its own distinctive pattern of sustained responding.128


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294. Panyan, M. C.: New Ways to haviors in "retarded" persons. Arrangements that have not been modified to be functional acquisition contingencies for handicapped people will fail to generate new skills. Moreover, skills already acquired may never be performed at "normal" rates if the contingencies that facilitated acquisition are not modified to accelerate and sustain their speed. If effective consequences are made available regardless of what the behavior is doing (noncontingently), skills will likely disappear and be replaced by whatever nonadaptive behaviors are being engaged in at the time the consequences are delivered. Proper design of behavior-dependent contingencies is critical in determining the success of behavior-analytic methods in habilitating retarded behavior.

Defining the Focus of Intervention

Many events may occur before and during a movement cycle, and a host of environmental reactions may follow. Still, some behaviors may appear to occur irrespective of antecedent events and may even appear to produce no reaction. The first business of behavior analysis is to determine which observable aspects of the environment a person is interacting with. Behavior analysis begins with an operational description of what the person is doing or is supposed to do, the conditions that should or may serve as initiating signals for the behavior, the observable changes in the environment following the behavior, and how often and when these environmental reactions occur. It then proceeds to determine the functionality of each physical component by systematically changing one at a time and observing the effect of every change on the measured frequency of the selected behavior. This is the basic methodology of experimental control derived from laboratory behavior analysis.

Identification of a defective component for a given person in a given environment constitutes behavioral "diagnosis." A defective component is one that is not currently functional in relation to the desired behavior, or one that is supporting an undesirable behavior. Manipulation of various parameters of a defective environmental component until its measured effect demonstrates the desired function for the desired behavior is the process of behavior-analytic habilitation. The environment is modified until the appropriate behavior-generative and behavior-supportive effects are shown in measured and durable behavior change.

Failures in applying behavior-analytic methods are, then, attributable not to hypothetical learner characteristics such as "intelligence," "defective ego strength" or "brain damage," but to inadequate design of a
habilitating environment. While considered by some to be a radical departure from more traditional views of treatment, the methods and principles of behavior analysis are based on decades of research on both animal and human behavior.

THE GROUNDWORK

Behavior analysis originated in studies of laboratory animals. In the late 1800s Pavlov, studying the digestive system of dogs, found that salivation, normally elicited by presentation of food, was lawfully elicited by other antecedent events that had been systematically presented with food.28 At about the same time, Thorndike found that hungry cats took less and less time to escape from a "puzzle box" when escape led to food.29 The relationship between a cat's behavior and its environmental consequences was elaborated into the well-known law of effect.295

But the impact of environmental events on behavior did not become fully evident until Skinner devised an experimental space in which an animal could freely obtain food pellets by depressing a bar.291,292 If food was made available only intermittently, barpressing could be sustained for long-term study. It could be accelerated, decelerated or made more complex depending on what the environmental design required the animal to do to get food. Ongoing behavior, uninterrupted by experimenter-controlled trials, was directly and automatically recorded in cumulative tracings that showed both the immediate and the long-term effects of variations in an animal's immediate environment. With methods paralleling those of experimental medicine,293 conclusive experiments could be performed on single organisms without recourse to statistically designed group studies.294

As Watson had foretold,217 behavior emerged as a subject in its own right—freed from mentalistic interpretations and described by the environmental operations demonstrably responsible for its change.

In 1953 Skinner articulated the advantages of rate or frequency of response as a basic datum, and he described the predictable patterns of behavior produced by different frequency and timing of environmental consequences (schedules of reinforcement).294,295 Highlights of his methodologic inventions were described in a 1956 paper.296 Application of carefully programmed consequences to animal instruction was engagingly described in 1951.293 Since then, studies of many species of organisms have continued to show that, if environmental events are carefully arranged in relation to well-defined behavioral acts, predictable and often complex patterns of behavior emerge.298


Lindsley's long-term studies was variability—fluctuations in hour-to-hour and day-to-day rates that varied widely from person to person and were
often associated with episodes of symptomatic behaviors that interfere with reinforced operant behavior.233. 234. 236

Nonetheless, these studies demonstrated that properly selected, intermittently scheduled consequences could sustain human behavior for long-term analysis. To reveal habituatably relevant individual characteristics, this capability became a methodologic necessity because of the temporal variability of disordered behavior, the wide range of individual differences in acquisition times, and the widely varying rates that distinguished one patient from another. Consequence-sustained behavior was demonstrated to be sensitive to the effects of drugs,231. 233. 235 to the effects of psychotherapy,233. 238 to therapeutic interview variables,242 to changes in circumstances of daily living within the hospital,231 and to specific behavior deficits,233. 234 and was correlated with clinical behavior ratings.274 With the laboratory prototypes of today's multiple baseline analyses,26 it was possible to monitor recovery,234 to determine the differential effects of drugs on both symptomatic and adaptive behaviors,234 and to provide consequences contingent upon symptom emission.232. 233

The first studies of retarded behavior demonstrated lawful relationships to different reinforcement schedules and illustrated the range of rates and differences in rate patterns shown by selected institutional residents during a relatively small number of sessions in a conditioning enclosure.115. 229 Variations in the environment were analyzed for their effects in facilitating discrimination230. 239—the first diagnostic-prescriptive application of free operant behavior analysis to determine which environmental events are functional for which persons.

Ferster and DeMyer extended the methodology to analyze the behavior of autistic children—another clinical population whose behavioral variability and individual differences in acquisition times necessitated long-term analysis.125. 126 In addition to food and candy dispensers, a headset for listening to music, a trained pigeon in a box, a kaleidoscope, a pinball machine, a television set, an enclosed electric train, a slide viewer and other devices were gradually incorporated into the fully automated environment. Children learned to press a key to obtain intermittently available tokens, which could then be inserted in slots to operate devices of the child's choice. This procedure developed a durable conditioned reinforcer (token). The 60- to 90-minute daily sessions of keypressing behavior sustained in this manner eventually showed schedule-related patterns similar to those shown by laboratory animals.

When the children's behavior stabilized, the investigators varied the environmental antecedents to require more complex behaviors. Both

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Extending the Environment's Functional Descriptive and Assessment Capabilities

Basic behavior characteristics. Sensitive paced manipulation of environmental contingencies can produce rapid change toward normality. On the other hand, a constant environment, offering a variety of ways to obtain reinforcement, permits individually different patterns—both defective and "normal"—to emerge. Such an arrangement permits behavioral retardation to be functionally defined in terms of responses to constant screening contingencies. Subsequent analyses may show differential effects of remedial procedures.

One such environment, designed to measure response differentiation and stimulus discrimination separately, permitted highly individualized behavioral patterns to emerge. Participants showed stereotypies, variable acquisition and clearly defined, enduring patterns of specific deficits, as well as normal patterns of behavior. Under constant contingencies, participants eventually were sifted into six mutually exclusive, behaviorally homogeneous groups. The six patterns of behavioral accuracy and deficit ranged from "normal" to severely deficient, but were not associated with psychometric classification, diagnosis, sex, age, duration of institutionalization or age at admission. At no stage during the course of acquisition was psychometric classification predictive of the way participants distributed themselves in the functionally defined accuracy/deficit categories. However, those classified as more severely retarded required significantly more time in the conditioning environment to show which contingencies were functional for them. Throughout the course of acquisition, the more severely retarded consistently operated the apparatus at lower rates than those who were less retarded. Lower rates were also associated with lower age and younger ages at time of admission to the institution.

Psychometrically associated rate differences were also shown when each participant was working for whatever consequence sustained his or her highest rates, whether candies and pennies, the video channel of TV when audio was "free," colored slides, recorded music or the audio channel of TV when the video was "free." But differences in the ward environments where residents live may override psychometric attributes in contributing to rate differences.

Analysis of defective components in the experimental environment shows that the emergent deficit patterns are differentially diagnostic of the nature of environmental change that produces more "normal" patterns of responding. While manipulations of this environment can produce acquisition in the majority of even the most severely retarded persons, the contingencies sufficient to produce more accurate performance...
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**Sensory acuity.** Still other adaptations of the behavior analytic environment can reveal sensory impairments as distinct from lack of basic discrimination skills. In one early study, children learned to make one response in the presence of one lighted panel and another response in the presence of another lighted panel. Then pure tones of varying frequencies, at an intensity well above normal threshold, were paired with only one of the lights. Trinkets and candies were made available only when the child pulled the "correct" plunger during the light-tone condition. Gradually, as the lights were faded out, the tones came to control responding and their intensity was decreased until the child's performance indicated inability to hear the tone.

Other operant audiometry procedures have used a single response button and offered projected slides or trinkets and candy for responding in the presence of a tone but not for responding in its absence. One sequence pretrained severely low functioning children to discriminate the presence of a light, then paired a tone with the light. The signal for responding was gradually shifted from the light to the tone, and then the intensity of the tone was gradually decreased until the children demonstrated inability to hear by failing to make use of the auditory antecedent. Similarly, behavior-analytic procedures have been used to estimate the visual acuity of nonverbal children. Barpressing in the presence of an illuminated panel produced candy, cereal or pretzels, while pressing in its absence produced nothing. As children acquired the light-no light discrimination, E's and reversed E's (comparable to those on a Snellen chart) were gradually substituted for the lighted and unlighted panels respectively. Visual acuity was estimated on the basis of accurate responding to E's of various sizes and at various distances from the child.

**Modality preferences.** Variations in the behavior-analytic environment have given more precise information about individual auditory preferences and about individual preferences for visual versus auditory stimuli. An arrangement whereby intensity of a continuously available stimulus varies as a function of response rate (conjugate scheduling) enables a person to indicate preference for ongoing visual or auditory scenarios. The "listening" patterns (both working to listen and stopping to listen) of moderately retarded community school children revealed uniform rejection of normal speech rates (180 words/min.) and preference for both slower-than-normal and faster-than-normal rates of story-
telling. In another study, six of 12 "learning disabled" children revealed listening deficits; only one showed normal looking and listening patterns. Instruction of such children might be made more effective through analysis of patterns of attending to varieties of auditory and visual material.

**Behavior-analytic crib environments.** Other adaptations of the behavior-analytic environment have located behavior-generating and sustaining events for profoundly disabled crib-ridden youngsters. With additional modifications, multiply handicapped children have been taught to match movement topographies to specific auditory consequences. Still other environmental designs have enabled infant panel-kicking patterns to show that the sight of a smiling adult is a behavior-generating consequence.

These exploratory analyses showed that behavior-analytic methodology was, indeed, applicable to the assessment and habilitation of severely disordered and deficient behavior. With continuously recorded behavior in suitably designed environments, questions are asked by different arrangements of environmental events. Answers are provided by directly measured changes in behavior that show whether particular modifications are functional in altering or sustaining an individual's behavior. Observer biases and recording errors are bypassed, and the behaver's automatically recorded actions become an objective medium of communication. However, for broader applicability, field treatment situations demand that the function of other individuals in the environment be analyzed.

**Behavior-Analytic Group Environments**

That people's reactions can generate and sustain as well as reduce or eliminate behavior was first clearly demonstrated by application of behavior-analytic procedures to ward management. Starting in the late 1950s a series of demonstrations by Ayllon and his colleagues showed that deviant behaviors could be reduced in frequency and often eliminated by explicit, systematic changes in the reactions of ward personnel. Although nurse-reaction contingencies were in effect 24 hours a day, specific behavior changes in individual patients took 6 to 11 weeks to emerge. Behaviors included "psychotic talk"; refusal to self-feed; stealing food; hoarding rubbish, magazines and towels; and wearing excessive clothing. Moreover, a stereotyped behavior (interpreted psychodynamically as "magical phallic, omnipotent, compulsive, symbolic of wish fulfillment") was generated, maintained and

**Behavior Analysis**


Behavior Analysis: A Comprehensive View of Behavior Modification

The Management and Instructional Domains

Experimental adaptations of animal conditioning methods to human behavior demonstrated the feasibility of applying the methodology to a wide range of behaviors in a wide variety of settings. However, most studies have involved groups who have already acquired the numerical skills that are essential to economic transactions.

Then eliminated simply by careful scheduling of selected reactions by the staff.

From demonstrations of individual behavior change, the procedures were extended to manage specific behaviors of all residents in a hospital ward. First food was made contingent on arrival at the dining room within a time period that was progressively shortened until residents appeared on time and ate without cajoling, tube feeding or other forms of attention previously given the unwanted behaviors. Access to food was then used as a consequence for other behaviors.

Starting in 1961, metal tokens were introduced as payment for certain off-ward jobs, routine ward maintenance and self-care. Ward residents could use the tokens to purchase items and privileges. Analyses of the behavioral effects of token contingencies, descriptions of behaviors that earned tokens, the privileges that could be purchased and the detailed training program that was developed from them are landmarks in the literature on human behavior management that should be studied by all potential practitioners.

The model that was developed for state hospital ward management was later adapted for use in training schools and a classroom for institutionalized retarded children.

Long reference lists and many excellent critical and instructive reviews attest to the popularity of the token economy in applied behavior analysis. However, most studies have involved groups who have already acquired the numerical skills that are essential to economic transactions.
Decelerating Excessive Behaviors

That many "symptomatic" behaviors have operant function has been demonstrated by analyses of their functional relationship to environmental events. For example, the frequency of stuttering decreased when every occurrence was *punished* with a blast of noise, and rose when every occurrence was *negatively reinforced* by escape from noise. Moreover, normally fluent persons acquired stuttering when every occurrence of nonfluent reading was negatively reinforced by escape from aversive conditions. The frequency of neurogenic multiple body tics decreased dramatically when every occurrence interrupted music the tiqueur had chosen to listen to. The duration of bedtime crying increased when the behavior earned a parent's bedside attention for longer and longer intervals, but episodes of crying ceased by the tenth time the child was put to bed and left alone (*extinction*). An obese woman stopped stealing food when every occurrence of stealing resulted in her being removed from the dining room (*withdrawal of reinforcement*), and she stopped hoarding towels when ward staff systematically dispensed some 600 of them over a four-week period (*satiation*). She also stopped wearing multiple layers of clothing (average 25 lb.) when access to meals was made contingent on her removing more and more superfluous garments (*reinforcement of incompatible behavior*). These and many other investigations have shown that appropriate changes in environmental reactions can control the occurrence of excessive behaviors.

**Stereotyped rocking**, like "compulsive" broom-holding by a psychotic patient and headbanging by monkeys, can be generated by the same procedures that are effective with more adaptive behaviors. Whether produced experimentally or acquired "spontaneously," rocking shows the same functional relationships to schedules of reinforcement as other forms of operant behavior. Moreover, rocking can become a discriminated operant that occurs only in the presence of stimuli that signal instruction as an approach to teaching of reading, writing, and arithmetic to retarded children. Psychol. Record 16: 505-522, 1966.


49. Becker, W. C., Madisen, C. H.: The availability of reinforcement. A number of antecedent (setting) conditions are associated with high prevalence of apparently "spontaneous" stereotypy among groups in institutions, and they are well reviewed elsewhere.47 Some persons acquire rocking simply by imitating their wardmates. Furthermore, repetitive stereotyped behaviors, if they are not disruptive, may produce little or no social reaction. Therefore, unlike high-frequency behaviors that do produce reinforcing reactions, some self-stimulatory behaviors cannot be decelerated simply by withholding attention. Extinction, as a deceleration procedure, requires that the behavior-maintaining reinforcer be known.

In some persons, rocking, like the pacing of psychotic patients, may continue unabated while they perform other behaviors sustained by their environmental effects. However, long-term, simultaneous recording of both rocking and a systematically reinforced manual task suggests that, while an alternative behavior is being differentially reinforced, rocking may disappear without direct intervention. Thus, some repetitive self-stimulatory behaviors appear to be incompatible with behaviors that are being reinforced by the environment. Moreover, they often interfere with responsiveness to antecedent events. However, like disrupting classroom behaviors, repetitive self-stimulatory behaviors may virtually disappear when reinforcement is made contingent on their absence (differential reinforcement of other behaviors) or when reinforcement is delivered for more acceptable forms of behavior. When the environment ceases to react to the adaptive alternative behavior, stereotyped behaviors return.

Some high-rate stereotypes appear to require contingencies that directly eliminate or reduce their frequency before the behavior can acquire more acceptable ways of interacting with the environment. Repetitive behaviors, including minor motor seizures, have been decelerated by contingent shouting ("Stop that!") coupled with bodily shaking, or contingent enforced practice of an alternative behavior (overcorrection). Momentary electric shock delivered to the body contingent upon every occurrence of the stereotyped movement may be effective when a behavior occurs at such high rates that it is difficult to reinforce alternative behaviors without risk of inadvertently accelerating the stereotypy. Once the interfering behavior is sufficiently reduced, existing alternative behaviors can be accelerated or new alternative behaviors taught.

Self-destructive behaviors also appear to be stereotyped. However, the reactions they evoke make their operant function apparent. When observers react with sympathetic comments or physical attention, the result
may be an increase in the frequency of self-destructive acts. When attention is withheld (extinction), self-destructive acts, like tantrums, eventually disappear. When attention accelerates more acceptable behaviors, self-destructive acts decelerate. Conversely, when attention to more acceptable behaviors ceases, self-destructive behaviors return to their previous rates. Elimination of social reinforcement may be slow and dangerous because the early stages of extinction are usually marked by temporarily increased frequency of the behavior being ignored ("frustration effect"). Brief periods of withdrawal from reinforcement (time out) contingent on each self-destructive act may be effective with relatively low-rate nonlethal behaviors, in which case reinforcement of nondestructive acts can take place concurrently. Continuous restraint not only precludes development of more appropriate behaviors but generally makes it impossible to analyze the role of specific environmental effects. Moreover, it may cause severe and irreversible physical deterioration. Systematic diminishing of restraint, concurrent with reinforcement of nondestructive behaviors, has often met with success.

The fastest decelerator of self-destructive acts may be a momentarily painful electric shock delivered to the child's body contingent on each self-destructive act. A small number of shocks may eliminate the behavior in the treatment environment. The effect may even generalize to other environments, but the decelerative effects of shock often are situation specific. Nonetheless, if the self-destructive acts recur in new settings with unfamiliar people, a single shock usually suppresses the behavior. Other objectionable behaviors, though untreated, may disappear along with the dangerous acts, and only positive side effects have been observed. If shock delivery is systematically paired with "No" or another sound, that event alone can become a conditioned aversive stimulus which can be substituted for shock to further decelerate self-injurious behaviors.

As soon as self-destructive behaviors are decelerated enough to introduce contingencies that accelerate more appropriate behaviors, the training that was previously impossible can proceed, thus providing the behaviors with alternative ways of affecting the environment without self-damage. However, if the post-treatment environment does not reinforce and further develop desirable behaviors, they will likely decelerate and previously established self-destructive behaviors may return.

Analyses of many high-frequency deviant behaviors and their successful management in wards, classrooms and home settings are ably reviewed elsewhere. An important re-

To the memory of my former colleague and co-investigator, Malcolm J. Farrell, M.D., who so keenly shared my investigative optimism that he provided continuous support for my work, I gratefully dedicate this chapter.

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students present the same materials to themselves. Moreover, skills acquired with this instructional format are not likely to be self-initiated or performed independently. Certainly they should not be considered as "mastered" until these constraints are removed and the student performs them at more normally fluent rates. Since there is evidence that some institutional environments may foster low behavior rates, it is especially important to include fluency criteria in the instructional objectives of institutional residents.

Standardized procedures for obtaining fluency data are being developed, and rate norms on basic preacademic and academic skills are being compiled. The relationship between fluency and skill transferability has not been systematically studied in severely handicapped people. However, it seems reasonable to expect that skills practiced at increasingly "normal" rates may be more useful and therefore more visible in the behavior's repertoire than those which are rate-limited by inadequately designed instructional materials and contingencies. There is evidence that contingencies which increase rate may, as a byproduct, also increase accuracy.

CONCLUDING COMMENTS

Behavior analysis has demonstrated fine control of the environmental variables that can make many behaviors normally accurate. To go beyond temporary prosthesis toward more permanent remedial effects will require use of more normal performance criteria by which to evaluate our instructional success with handicapped people. The behavior-change technology now being developed holds great promise for people once considered unable to learn—a promise that may be fulfilled only if we continue refining and sensitizing our methodology to maximize communication with those whose most articulate "voice" is their measured interaction with the environments we provide. Our problem is to pose them the most habitually relevant questions.

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Teacher attention, contingent on instruction-following, was also effective. Attentive behaviors of 11 of 12 retarded children in a class were increased by the teacher's nonverbal approval but decreased when only verbal approval was given. Attention from peers may also function as an accelerating or decelerating consequence that influences teacher effectiveness.

Workshop productivity of multihandicapped clients has been increased by rate-contingent redeemable points, by stepped-up production-rate criteria that must be met to avoid working in isolation and by production-contingent extra break-time. Analyses of task difficulty, schedules of reinforcement and production rates revealed that interactive effects of these factors must be taken into account in programming workshop pay schedules.

Children's academic response rates are also sensitive to operant contingencies. Oral reading rates of deaf children, scores of Down's syndrome children on a commercially available arithmetic sequence and picture-naming by severely retarded and "autistic" children can be increased with appropriate schedules of reinforcement. Moreover, standardized test scores, including IQs, can be increased by systematic reinforcement.

**Temporal Dimensions and Terms**

Management procedures are most generally applied to existing behaviors that occur at deficient or excessive rates or at inappropriate times. The environmental interventions involve changes in the nature or arrangement of subsequent events and often in the antecedent conditions present when the behavior occurs. To determine if a given arrangement is functional, a given set of operations must usually remain in effect throughout many recorded emissions of the target behavior (often over many days, weeks or, in some cases, months). Only then can appropriately designed analytic procedures be applied.

This domain of applied behavior analysis has many different labels. Contingency management is a general description of the procedures employed. Behavior management, behavior modification and, in some vernaculars, behavior therapy describe the outcomes (rather than the methodology per se) when procedures are used correctly. In any event, the procedures are directly derived from the experimental analysis of freely emitted behavior that changes in rate, duration or intensity as a result of its effect on the immediate environment (free operant behavior).
In addition to identifying the prerequisite skills for existing curricula, task analysis, like a carefully programmed instructional sequence, can help to identify both the existing and missing "enabling" skills of individual students. Backward analysis of sequential prerequisite instructional objectives, from those at the lower levels of existing curricula to those required for mastery of basic skills, should provide an instructional sequence that starts by teaching attending behaviors (tracking, scanning, listening, etc.) and simple component motor behaviors (touching, grasping, releasing, etc.), then moves the student upward through the skill hierarchy to the prerequisites for elementary public school curricula.

"Behavioralized" definition of instructional objectives, a popular indicator of "programming" sophistication, is a much needed step in the right direction. However, establishment of behavioral objectives, while necessary, is not sufficient. One has simply to review lists of objectives to realize that, although they may be finely task-analyzed statements of final performances expected under specific conditions, unless they are arranged sequentially in such a way that subordinate skills contribute to superordinate skills, they are little more than lists of splinter skills unrelated to the cumulative skill development expected from a hierarchically arranged curriculum. Instructional sequences that do not incorporate dependence of superordinate skills on previously learned subordinate skills may fail to maintain the skills learned in early stages. Work on task-analyzed curricula for early childhood education has been ably reviewed elsewhere. There is now an excellent task-analytically derived instructional hierarchy in early math skills that not only serves as a procedural model for extended study but provides a well-defined sequence of skill objectives from which only minor departures for severely handicapped people may be required. Component skills analysis and programming for severely disabled low-functioning students illustrate the applicability of these techniques, originally developed to train military personnel to troubleshoot complicated electronic equipment—techniques that furnish guides on what skills to teach and when to teach them and, as an intrinsic byproduct, require continued use of component skills.

Mastery Criteria

An effective instructional hierarchy requires mastery of each prerequisite in the skill sequence. Specifying the behaviors to be performed and the conditions under which they are expected to occur as a result of

INSTRUCTIONAL CONTINGENCIES

Management contingencies may ease the jobs of parents, teachers and ward personnel, but they are not sufficient to expand the limited skill repertoires associated with behavioral retardation. While management contingencies often permit previously learned skills to re-emerge, severely low functioning persons rarely acquire new skills without contingencies designed specifically for instruction.

Sequentially Changing Instructional Contingencies

Behavior analysis has been eminently successful in generating complex new skills in laboratory animals. Pigeons have been taught the concept of "human," as well as quality-control inspection of pharmaceutical capsules and diodes. Chimps have learned to use binary numbers to communicate via sign language and symbolic objects and to execute complicated behavioral sequences during flights in space capsules. Analysis of these and similar undertakings reveals many ingredients of successful instructional methodology. In all cases, new behaviors are synthesized from combinations of existing behaviors by sequential changes in the nature of the task requirements to produce reinforcement. Unlike stable management contingencies that address existing behaviors and alter their consequences for regulatory effects, instructional contingencies involve sequential changes in responses, in stimuli or in their increasingly complex relationships.

The behavior-generating sequences developed with laboratory animals found their analogs in the technology that became known as programmed instruction, which was first associated with "teaching machines." Systematic application to retarded behavior began in 1962 with a programmed curriculum and classroom token economy.

Defining the Outcome of Instruction

Clearly defined behavioral objectives, mandatory in the research from which programming technology was derived, are among the basic contributions of that research to education. Circuits automatically
scheduled the antecedent and subsequent conditions in the learning environment. But automation could not have produced reliable contingencies without devices that, by their design, precisely defined the behavior that could activate them and the conditions under which they could produce reinforcement.

In application, it is impossible to measure a student's progress or the effectiveness of instructional methods without a precise description of the behaviors to be taught and the conditions under which they should be engaged in. Especially in a handicapped population, one or more components of the instructional environment may be ineffective for a particular student. A quantifiable objective allows a student's behavior changes to reveal which modifications in an instructional environment contribute to acquisition.

The First Operant—Finding an Accelerating Consequence

To find a starting point, a student's behavioral repertoire is scrutinized for a rudimentary component of the final performance objective—a behavior that, if strengthened, will facilitate progress toward the instructional objective. Whatever the act, its operant function must be established by finding a subsequent event that, when repeatedly delivered contingent upon the behavior, will increase its rate. Examples of behaviors that could be selected for initial acceleration are: leg extensions that are necessary for walking,239 vocalizations that could eventually be differentiated into speech sounds,249-250,329,345 finger-thumb opposition that should eventually become grasping and pencil strokes that are components of letters. Bits of food, drops of milk117 and episodes of vibration27 are examples of subsequent events that may become accelerating consequences if delivered systematically and contingently.

The first operant is, then, the initial target of instruction as well as a vehicle for determining what subsequent events are effective accelerators for a given student.

Successively Changing Response Criteria: Shaping

Once the first operant is emitted reliably, its reinforcer is delivered selectively, contingent upon changes in the initial behavior that contribute to or are increasingly similar to the desired behavior.353-362 Successive changes in intensity,290 amplitude, latency,296 duration,314 accuracy and complexity368 illustrate behavioral dimensions of an operant re-

now defined not by the student's psychometric score or medical diagnosis but by the teacher's skill in designing an effective instructional environment. Elementary skills of reading, writing and arithmetic are not only basic to community living but also offer entry into more "normal" public school curricula. Since the technology for teaching these skills to severely handicapped people is now emerging, their omission from curricula for this student group is no longer justifiable. Furthermore, since disrupting behaviors may be eliminated by strengthening academic skills,12-18 selection of functional academic target behaviors should produce a welcome byproduct. In contrast to treatment of behavior problems by short-term contingency management in prosthetic environments, the instructional gains developed with carefully planned longitudinal curricula82 may present fewer problems of maintenance and generalization.

Task-Analyzed Skill Hierarchies

Where to start and how to proceed are the most critical questions in designing instructional programs for people once considered "custodial." While the principles of programmed instruction183 and procedures for developing discriminations and behavior chains furnish leads on how to teach, they have not produced useful guides on what to teach and when to teach it. However, complementary procedures, developed from research on military training during the mid-fifties,138-140 conducted independently of the research on programming variables,185 are now being applied to help answer these questions.

Originally conceived as a way of determining optimal conditions for learning, task analysis begins with a behaviorally defined final performance objective and dissects it into its component skills. Working backward, the analysis continues to specify the prerequisites for the prerequisites until it reaches the most rudimentary skills that contribute to final performance. If properly executed, its product is a hierarchy of instructional objectives141,142,160 that starts with the subskills in a student's entering behavioral repertoire. The hierarchy specifies a sequence of instructional objectives that eventuates in the desired instructional outcome. In a well-analyzed sequence, mastery of each prerequisite skill should facilitate acquisition of the skill just above it in the hierarchy. Since every skill in the sequence is a component of or contributor to the skill above it, skills learned early in the sequence are, presumably, being used repeatedly and therefore should not disappear from the behaver's repertoire.
While both desirable and undesirable behaviors of severely low-functioning persons can be changed by altering their consequences, the effects are usually so highly situation-specific that they do not generalize to new settings or to people who have not been systematically involved in the behavior-change procedures unless such training is a planned part of treatment procedures. For this reason, contingency history, including the contingency-associated settings and people, is a salient "learner characteristic" that should become a thoroughly documented part of every problem-oriented educational record. Without such information, it is easy to assume mistakenly that behaviors emitted in a given environment represent the full repertoire of the behaver. Many previously acquired behaviors may not be emitted because of absence of antecedent or subsequent events that were highly discriminated components of the original instructional environment.

The problem for habilitators is, then, one of eliminating their own assumptions of behavior ceilings or limitations, detecting occurrences of appropriate actions and arranging behavior-accelerating consequences so as to require more functional, more adaptive emission rates. Because appropriate behaviors are generally incompatible with maladaptive behaviors, the more reactive the environment to positive, though initially infrequent response approximations is required in order to shift the criteria for reinforcement appropriately. Sensitive recognition of initially infrequent response approximations is required in order to shift the criteria for reinforcement appropriately. Especially with severely handicapped persons, the criteria for each successive approximation must be slowly advanced, always remaining within the range of movements being actively emitted by the behaver.

**Diminishing Antecedents: Prompts and Primes**

Rather than waiting for emission of an initial operant and relying on the shifting response criteria involved in shaping, a teacher can often speed up the acquisition process by successively changing the antecedents in the immediate environment to ensure execution of successively approximate behaviors.

For example, a motorically intact four-year-old would crawl toward and manipulate toys placed near her, but she had never walked. The height of the toys from the floor was gradually increased until the child had to stand to reach them. The horizontal distance of the toys from the child was increased to require her to take a step while using the table for support. Then the toys were placed on tables farther away, requiring the girl to take more steps to reach them. The sight of the toys functioned as a prompt discriminative for crawling, reinforced by manipulation of toys. Successively increasing the height and distance of the prompt required the child to engage in behaviors that successively approximated walking. Within only a few weeks, normal walking itself earned a variety of natural consequences that replaced the acquisition "crutches" of sequentially changing environmental conditions.

Similar methods of diminishing antecedent environmental "props" have been used to train a child with cerebral palsy to walk unassisted, a spina bifida child to use crutches and an autistic child to wear glasses after cataract surgery. Successively diminished completeness of verbal prompts is a familiar way of teaching articulation of polysyllabic words to persons with imitative skills. Fewer syllables are demonstrated on successive trials as the person is required to complete more of the word without help. The more quickly a prompt can be eliminated, the more rapidly self-initiation occur.

Some severely impaired children may display few shapable fragments

**Priorities for Alternative Behaviors**

One long-recognized facilitator of behavior maintenance is repeated use. Many skills disappear because they are not used. Ayllon and Azrin's rule of "relevancy" in selecting what to teach by behavior-change programming is a reminder of a familiar phenomenon: behaviors that are not reinforced in the natural environment will cease to be emitted. While "good behavior," "good sitting," "good looking" and other "on-task" postures may set the stage for instruction, as training objectives in their own right they are suspect—especially in a clinical population known for its doity and lack of self-initiative.

What, then, are some alternative behaviors? While self-help skills are a beginning, lowering of curriculum ceilings to accommodate constricted behavioral repertoires can no longer be justified. Behavioral limits are
of behavior. And even if desired behavior elements do exist, arrangements that would strengthen and build upon them are often too time-consuming to be practical. However, in order that environmental events may be brought to bear, an acceptable movement cycle must be made to occur.

The first instance of a response can be built or primed by antecedent events that elicit the desired movement cycle. Then, by arranging systematic presentation of appropriate subsequent events, the primed movement cycle can be built into an operant response that is maintained by the consequences it produces.

“Putting through” or physically guiding complete execution of a movement cycle is a familiar way of priming the first instance. To prime hand-tapping or arm-lifting, a student’s hand or arm is guided through the movement cycle. The movement is immediately followed by a potentially reinforcing event. If that subsequent event functions as a reinforcer, the degree of guidance can be gradually diminished into prompts or “fragments of primes” and eventually eliminated as the new response comes under the control of its environmental effects.

For students with some receptive vocabulary, an instruction may serve as a prime that evokes the first movement cycle to be given operant function. Modeling (demonstrating) a behavior may serve as a prime for students who have learned to imitate. But there are students for whom neither instructions nor demonstrations have begun to function as stimuli. The behavior of coming when called was initially evoked in two autistic children by pairing the instruction “Come here!” with the onset of electrical stimulation under the feet. A “priming instructor,” standing behind the child, pushed the child in the direction of the “calling instructor,” and the shock was turned off when the child reached the caller. Escape from shock quickly built the originally primed approach movement into an operant response. Then the environment was modified so the child could avoid shock by moving increasing distances to reach the calling instructor. Once the child’s instruction-following behavior had acquired operant function and the instructor’s antecedent “Come here!” had become a discriminative stimulus, more advanced training in social behavior and language could begin.

Converting Antecedent Events into Stimuli

Arrangements that generate and strengthen new responses may produce behavioral deviance unless the new behaviors are made to occur only under appropriate circumstances. A child who appears to imitate questionable for clinical populations characterized by behavioral deficits and deficiencies. If not complemented by contingencies that strengthen adaptive and constructive alternative behaviors, decelerative behavior control risks eliminating the behaviors’ only effective means of manipulating their environments. The results may be not only counterproductive but also antithetical to the goal of behavioral normalization.

Contingencies that suppress self-stimulatory, self-destructive and hyperactive behaviors in children labeled retarded and autistic may have positive side effects such as facilitation of discrimination learning, increased spontaneous play, use of toys and initiation of contact with others, but even in “normal” third graders, reduction of disrupting behaviors does not necessarily result in increased skill acquisition.

A more positive approach, and certainly a more defensible one, focuses on contingencies that strengthen specific alternative behaviors, with the “free” byproduct of simultaneously reducing “untreated” problematic behavior. Many studies have demonstrated reciprocal covariation of behaviors. For example, when reinforcement is delivered for clapping or rocking in time to music, or even pressing a bar, self-destructive behaviors may decelerate to near zero. When ball-pulling is systematically reinforced, rocking may disappear. Substantial reduction in the self-stimulatory activities of autistic children has been observed during discrimination training. A classroom program that reinforces only academic performances can eliminate undesirable behaviors and has been found as effective as drugs in controlling the behavior of hyperactive children.

Reciprocal covariation of positively and negatively valued behaviors is shown by deceleration of deviant behaviors as a side effect of strengthening constructive or adaptive behaviors. In severely handicapped children it appears that the more barren the repertoire of alternative behaviors, the more likely the development of deviant behaviors that produce effects from the environment. Conversely, the greater the frequency and range of positive alternative behaviors that produce reinforcement, the less likely the development of high-frequency deviant behaviors. The inverse relationship holds not only for individual behavior but also for groups of institutionalized children from differing residential climates. The educational value of focusing on behavior-strengthening contingencies is obvious. Early intervention programs that teach more normal behaviors to severely handicapped toddlers will likely demonstrate preventive functions as well. Among the very young children in one such program, it is difficult to find any behaviors that should be decelerated.
fective in producing behavior changes in severely handicapped persons do not exist in the "real" world. They are prosthetic environments where contingencies are systematic and controls are *de rigueur*—environments that facilitate acquisition by compensating for deficits. \(^{229}\) Ideally, gradual transition from the stringent programming necessary for acquisition to the less precise programming necessary for maintenance would enable the behaver to find sustenance in the "normal" world of endlessly varied settings and highly intermittent and usually intrinsic, social or monetary reinforcement. Otherwise the prosthetic conditions of training must be maintained by restructuring the post-treatment environment. \(^{255}\) Alternatively, a student's family can be taught to continue the treatment conditions in order to maintain treatment effects. \(^{255} \cdot 222 \cdot 454\) or parents can be taught to produce the effects themselves.\(^{17} \cdot 33 \cdot 282\)

One might wish that entire communities could be re-educated to use behavior-supporting contingencies for the severely handicapped or even preventive contingencies that would obviate the need for radically different behavior-change environments. But such massive social change is unlikely in a world already overpopulated with individuals increasingly concerned about their own survival. As an alternative, prosthetic communities might be designed to teach and maintain acceptable and constructive activities among people with retarded behavior—communities conceptually similar to those designed for handicapped elderly people.\(^{246}\)

The extent of environmental prosthesis necessary to maintain and generalize treatment gains may be inversely related to the "unreality" of the treatment conditions. If so, gains obtained with minimal environmental change are more likely to be sensitive to "natural" contingencies and thus more readily maintained in the post-treatment environment than those obtained only in highly controlled and finely tuned—but by definition "unnatural"—environments.

**Positive Indirect Behavior Control**

For the most part, behavior management has emphasized deceleration or elimination of undesirable behaviors. The focus on control has been attributed to the nature of problems referred by parents, institution staff and school personnel who have sought panaceas for disruptions in their own lives.\(^{452}\) Carried to their ultimate, decelerative management procedures can produce scenes of behavioral vegetation—wards, classrooms, homes where sitting quietly avoids aversive consequences for the troops and brings peace to the sergeants. The behavior control priority has been challenged as an unsuitable educational goal.\(^{452}\) It is especially but is really echolalic or echopraxic, a student who continues to count objects after the requested number has been reached—such cases provide examples of behaviors that have been strengthened but not made responsive to appropriate environmental cues. To progress from behavioral deficiency to adaptive functioning, the student must be taught not only to engage in a variety of behaviors but to discriminate the appropriate conditions for each behavior.

While most normal children quickly learn when and when not to behave in certain ways simply by being told or shown, and many handicapped children learn simply through differential reinforcement, more specialized procedures are often necessary to teach discriminated behavior to severely disabled children. Studies cited earlier\(^{61} \cdot 225 \cdot 292 \cdot 389\) showed how gradual changes in the programming of successively presented antecedents could establish them as discriminative stimuli—cues which control the onset and cessation of specific behaviors. The component tasks in those cases consisted of performing an established response in the presence of a condition associated with reinforcement and pausing in the presence of a condition not associated with reinforcement. Responses in the presence of events not associated with reinforcement were defined as errors. Performance accuracy was determined by comparing the rates of behavior during the two conditions.

An early study showed that pigeons could acquire a successive discrimination without errors if the "wrong" conditions were faded in gradually as accurate responding persisted.\(^{389}\) A similar fading procedure taught preschool children the difficult task of discriminating simultaneously presented triangles that differed only in degree of rotation.\(^{279}\) The correct choice always appeared at full intensity while the two incorrect choices were at first invisible then gradually brightened until they were as bright as the correct choice. The brightness difference, which had served a prompting function, was then faded out until rotation was the only basis for correct choices. Fading was shown to be the major variable in establishing control of responding by the new visual cue. Prompting and fading of prompts became a technology in its own right as programmed instruction sought to remedy the inefficiency of traditional pedagogical methods that permitted or even produced errors.\(^{183} \cdot 358\) But in programming instruction for severely disabled children, a new and persistent problem emerged: the antecedent events that could serve as prompts for pigeons and normal children were ineffective for many severely handicapped students. The problem was one of developing the stimulus functions of visual and auditory events that could then be used to increase the effectiveness of teaching methods.

**Visual event conversion.** With a simultaneously presented eight-choice
array and carefully developed sequences of fading, a “subtrainable” microcephalic man was taught to discriminate brightness from darkness, then presence from absence of a circle as the brightness difference was decreased, and finally circles from ellipses as “incorrect” stimuli (ellipses) were gradually faded in.\textsuperscript{349, 350} As the ellipses were made more and more circular, continuing correct responding showed increasingly subtle discrimination. Continuous measurement of errors and successes throughout six preliminary versions revealed parts of the sequence that needed revision. The problems encountered en route to the final version mto functional instructional stimuli is an even greater problem with disrimination. Continuous measurement of errors and successes highly successful in rapidly teaching a wide variety of simultaneous vis-
ual discriminations to severely handicapped students.

Stimulus transfer from visual to auditory events. Converting auditory events into functional instructional stimuli is an even greater problem with disabled children, many of whom appear “deaf” or have not learned to listen. As in the production of new responses, the process of converting antecedent events into stimuli must start with whatever behaviors and events are already functional for the individual. People who attend to visual events but who show no signs of listening may have no sensory impairment, but even with strong and well-programmed reinforcers, the auditory environment may continue to be nonfunctional unless the person’s existing visual skills are brought to bear.

Progressively delayed presentation of established visual (“instructional”) stimuli following presentation of auditory events can develop rapid transfer from visual to auditory stimuli.\textsuperscript{399} The delay procedure was first found to be effective in shifting a verbal labeling response from imitative control to control by objects and pictures (teaching a verbally imitative child to label parts of the instructional environment).\textsuperscript{324} It initially teaches imitative pointing to one of an array of colors as the trainer’s pointing is paired with the instruction, “Point to —.” When student pointing is reliably established, the instruction is given as usual on each trial but the visual event (trainer’s pointing) is delayed four seconds to give the behaver a chance to show whether the auditory event (instruction) is functional. Gradually the proportion of “waits” for the visual

These are but a few examples of increasingly “normal” behavior being developed in people who until recently were denied educational opportunities because of deficiencies in the methods used to teach them\textsuperscript{220} and assumptions based on expectancies associated with low psychometric scores.

MAINTENANCE AND GENERALIZATION OF BEHAVIORAL GAINS

Evidence abounds that behaviors can be taught by appropriate arrangements of environmental events. But the usefulness of a behavior depends on the extent to which it allows the behaver to engage in “normal” social, academic and vocational activities. No matter how effective the teaching techniques or how sensitive and communicative the measurement system used for their evaluation, if newly taught skills are not visible in the behaver’s repertoire, both credibility and cost-effectiveness may be questioned.

Maintenance of behavior after training, and generalization of newly taught behaviors to different tasks in different settings with different people present, are perhaps the greatest stumbling blocks in current behavioral habilitation. And these problems loom larger as more and more people are moved from institutions into the community.

Many procedures have been tested for effectiveness in sustaining behavior changes.\textsuperscript{207} Natural consequences—consequences commonly found in “normal” environments—have been systematically substituted for the contrived consequences (typically food or tokens) often used in training. For example, a smiling response that was originally taught with food reinforcement was eventually sustained by the reactions of others.\textsuperscript{192} Other procedures that have been tried with varying degrees of success are: peer praise for appropriate behavior;\textsuperscript{203} scheduling less frequent opportunities to use tokens for purchasing and thus gradually removing the training contingencies;\textsuperscript{203} equating stimulus conditions in the extra-treatment environment to correspond with those where behavior change was first achieved;\textsuperscript{416} training appropriate reactions in peers and training teachers in the use of contingencies;\textsuperscript{416} shifting to intermittent schedules of reinforcement more likely to be experienced in the natural environment;\textsuperscript{294, 212} and including a number of people as change-agents.\textsuperscript{51, 255, 379}

Definitive information on this important problem remains sparse. Most successful treatment conditions may be composed of combinations of variables, each of which may be differentially effective for different individuals.\textsuperscript{317} In general, the highly structured environments found ef-
Reading has traditionally been considered beyond the capabilities of students with test scores below the "educable" range. However, recent studies show that sight vocabulary and reading comprehension (of sentences as well as single words) are realistic instructional objectives for students with psychometric scores in the severely and profoundly retarded range.\textsuperscript{41} \textsuperscript{,} \textsuperscript{86} \textsuperscript{,} \textsuperscript{87} \textsuperscript{,} \textsuperscript{90} \textsuperscript{,} \textsuperscript{95} \textsuperscript{,} \textsuperscript{347} \textsuperscript{,} \textsuperscript{348} A valuable behavioral analysis of some basic reading skills furnishes not only well-defined instructional objectives and assessment procedures for each subskill but also a schema for detecting subskills that may emerge from various combinations of entering skills and instructional objectives.\textsuperscript{347}

That reading skills can serve in surprising ways is illustrated by a young institutionalized Down's syndrome student (PPVT below 12) with a history of rapid acquisition of receptive and expressive sight vocabulary. In our classroom, the child failed to acquire receptive comprehension of spatial prepositions until the various positions were labeled with appropriate printed words. After a few sessions, the labels were removed, and receptive comprehension of such words as \textit{inside} and \textit{outside} remained.

Math skills such as use of numerals, counting, adding and quantitative concepts obviously facilitate functioning in the community. Labeling numerals, writing numerals from dictation,\textsuperscript{83} selecting quantities of objects corresponding to numerals,\textsuperscript{313} \textsuperscript{,} \textsuperscript{314} adding printed numerals,\textsuperscript{84} telling time,\textsuperscript{89} \textsuperscript{,} \textsuperscript{154} using a ruler,\textsuperscript{155} using telephones,\textsuperscript{281} and counting out money to match price tags\textsuperscript{50} are examples of numerical and quantitative skills now being taught to people once considered only "trainable," "subtrainable" or "custodial." Although there is still little information on instructional procedures and optimally sequenced curricula for teaching math skills to severely retarded persons, sequences of skill-defined instructional objectives are under development.\textsuperscript{65} \textsuperscript{,} \textsuperscript{288} \textsuperscript{,} \textsuperscript{429} Successful mastery of the component prerequisite skills should make severely handicapped children eligible for advanced training in coinage.\textsuperscript{271} \textsuperscript{,} \textsuperscript{435} Money value, use of recipes and other personal and domestic skills required in community living.

Handwriting, another skill once thought unattainable by people who score below a certain IQ range, is now being acquired by severely handicapped students.\textsuperscript{88} An instructional sequence being used successfully with preschool children\textsuperscript{82} may be a useful guide if modified to accommodate the entering skills of severely handicapped people. One carefully analyzed sequence progresses from prerequisite skills through visual discrimination of shapes, lines, letters, receptive letter recognition, tracing, copying and printing letters from dictation.\textsuperscript{271} In handwriting, as in reading and math, severely handicapped people have yet to show an upper limit or skill ceiling.

Instruction declines and the proportion of anticipatory responses—those dependent upon the auditory name—increases. Delaying presentation of a well-established stimulus following presentation of a “new” one converts the previously nonfunctional “new” event (naming by trainer) into a discriminative stimulus. Previously “nonlistening” children thus learn to respond appropriately to oral instructions, thereby demonstrating that they have learned to listen.\textsuperscript{399} The procedure has also taught a variety of new instructions to severely handicapped students who had already acquired some limited instruction-following behavior.\textsuperscript{381}

\textit{Individualized stimulus functions}. Because of the wide range of individual differences among handicapped children, whatever physical attributes of instructional materials function for a student as a signal for correct responding should be used in initial training—even if those attributes are unnecessary for final performance. Materials incorporating multiple “redundant” relevant attributes in the early phases of instruction will be useful with more students than materials incorporating only one “crutch” attribute. For example, one set of materials teaches severely retarded children to select printed words that match their spoken names. The correct word is printed in a different size and in a different color from the incorrect words. Further, the shape of each word is highlighted by a bright yellow background.\textsuperscript{93} \textsuperscript{,} \textsuperscript{95} The presence of three different “crutches” allows the same materials to be used with children who have already acquired either size or color or shape (configuration) discrimination. Transferring stimulus function from any of these cues to the uncued printed word is accomplished by fading out the redundant cues as instruction progresses.

Multiple cues permit testing (probing) the functions of each cue or combination of cues at various points in instruction to determine which are still necessary for a student. Such a program offers continuing diagnostic-prescriptive opportunities that should increase the efficiency of the teaching process by enabling students to use a greater variety of stimuli as initial acquisition “props.”\textsuperscript{239} With highly selective autistic children, determining which antecedent events are functioning as stimuli may be critical for effective instruction.\textsuperscript{258} \textsuperscript{,} \textsuperscript{259} \textsuperscript{,} \textsuperscript{336}

\textit{Combining DiscriminatedBehaviors into FunctionalSequences}

Most adaptive behavior consists of sequences of responses each of which may be quite elemental. Dressing, toileting, bed-making, and the sequence of picking up, storing and exchanging tokens for preferred reinforcers exemplify complicated behavior chains, each component of
which is a discriminated operant (a response maintained by a reinforcer and signaled by a stimulus). Each response in the sequence must become the stimulus for the succeeding response until the last response in the sequence produces a known reinforcer. Reliable performance of the entire chain is the instructional objective. However, absence of component links will result in failure. Procedures described earlier for response shaping, priming, building and strengthening as well as those for establishing the signaling (discriminative) function of antecedents may be applied to teach each of the missing components separately. Chaining sequences can then be applied to behaviors already in the trainee's repertoire.

To maintain consistent immediate reinforcement for completing the sequence, many complicated behavior chains are taught backward. The last (reinforced) response is taught first, the next-to-last taught second, and so on. Thus the reinforced response remains constant while each of the preceding stimulus-response components becomes linked to all the others as the behaver executes them in appropriate forward sequence. Early applications of backward chaining taught severely retarded children to put on their pants and asocial chronic psychotic patients to engage in a "social" response and a token exchange to gain access to the dining room.

If a chain of behaviors is taught in the same order as required in final performance (forward chaining), the instructional environment must progressively change the criterion for a reinforceable response, much as in shaping, or else require step-by-step performance of the complete chain while gradually diminishing guidance or prompting throughout. An early example used forward chaining to prime the first instance of verbal imitation in nonimitative, mute, retarded children by first teaching the children to imitate a chain of motor responses and then adding a verbal component at the end of the motor chain. When the verbal components reached a close approximation of the trainer's model, the motor components were successively eliminated until only the verbal imitation was performed. A recent publication presents validating data on a forward-chaining sequence that teaches toothbrushing.

Testing Procedural Assumptions by "Asking" the Behaver

This section has described methods for making movement cycles into functional responses and for converting antecedent events into stimuli which occasion certain responses. In an environment designed to teach learned to use compound sentences and severely retarded children have learned complete-sentence answers to questions. Procedures found to be successful in teaching two-way communicative sign language to a chimpanzee have been adapted to teach nonspeaking children to acquire gestural communication skills that appear to trigger vocalization in those with intact hearing. Methods for training chimpanzees to communicate via symbolic plastic shapes have been successfully adapted as a prosthetic nonspeech language medium for severely and profoundly retarded persons. An instruction program for its use is now commercially available.

Although generally assigned simple, repetitive tasks, persons with retarded behavior have acquired constructive vocational skills once considered beyond their capability. Commercial production of high-quality electromechanical components (including relay panels, signal and toggle switch panels and lead-mounted diodes) by moderately retarded institutional residents began in 1964. Severely retarded adults have been trained to use a drill press and recent research has shown that accurate assembly of 15-piece bicycle brakes and 52-piece cam switch actuators at competitive production rates can be taught to people once thought to be untrainable. Even profoundly retarded, deaf-blind persons are now acquiring such vocational skills.

Clearly, work opportunities for people with retarded behavior have been limited more by low expectancies and lack of methodologic sophistication on the part of supervisors and sponsors than by their clients' deficiencies.

An instructive series of behavior-change projects shows how behavior-analytic methods may be used to answer questions germane to the design of more effective workshop environments. Particularly important is the demonstration that clients can be taught social and academic skills while they are performing contract-specified tasks without any loss in productivity. Dramatic advances in vocational training made possible by systematic application of research-based methods have been provocatively reviewed by Gold.

Assumptions about retardation have also limited the teaching of basic academic skills, crucial to social and vocational functioning in the community. Early applications of behavior management and programmed instruction procedures by Birnbrauer and his colleagues showed that skills such as reading, writing and arithmetic could be taught to institutionalized youngsters who had made little or no progress in other educational programs. And technology is now emerging to provide classroom instruction for severely low-functioning children heretofore considered incapable of acquiring anything but the most rudimentary self-help skills.
Augmented Behavioral Repertoires

With potential habilitative personnel multiplied many times by a technology that enables "nonprofessionals" to serve as behavior-change agents, people with severely retarded behavior can acquire self-help, social, academic and vocational skills never before thought possible.

Self-help skills have been the most popular focus of training endeavors. Self-toileting is now readily taught; inexpensive training aids are available for those who wish to use them; and one "crash" program has shown results within two weeks. Self-feeding and other appropriate toileting behaviors are also readily taught. Commercially available for teaching eating, blowing, feeding, diapering, toothbrushing, and washing, many persons with retarded behavior need no longer be totally dependent on caretakers.

Social and recreational skills can also be taught to disabled children when the immediate environment is appropriately arranged. Use of toys, social interaction, greeting behavior, appropriate smiling, and cooperative play are examples of such skills that have been taught to "retarded" and "autistic" children.

Research on communication skills has been particularly extensive, and many excellent reviews and resources are available. Two systems analyses that diagram sequences of component behavioral objectives in the training of receptive and productive language furnish guides for instruction and assessment of mute, inattentive, nonimitative, severely retarded children. Objectives within the curricula can be organized as sequences of procedures specified precisely enough to be used by previously untrained instructors. A detailed language instruction program, first outlined in 1972, now includes instruction in gestural communication. Although criticized as stopping short of a useful level of language competence, this program, which first teaches the function of ongoing behavior measurement, can be demonstrated only in measured behavior changes. To permit a behavior to communicate this critical information is the function of ongoing behavior measurement.

MEASUREMENT: THE BEHAVIOR'S MESSAGE

Especially in applications with severely disabled persons, whose behavioral changes may be both subtle and slow, the choice of a measurement system must be made with careful deliberation and full awareness of the sensitivity and clarity of its communication. The choice, in the final analysis, may be the choice of a "language" for people who do not speak. Therefore, in addition to arranging environments which maximize desirable behavior change, those who apply behavior analytic procedures must design measurement systems which maximize opportunities for a behavior to communicate. Sensitive, ongoing measurement is the function of behavioral change as it relates to events in the habilitative/instructional environment provides an empirical basis for selecting and timing procedural changes, as well as for judging the effectiveness of the changes. The behavior-changer who learns to use ongoing measurement finds powerful reinforcement in records that show successes often not revealed by unquantified observation—small changes that mark the beginning of acquisition, and the stability of performance that signals readiness for the next step. Equally important, the feedback of continuous measurement
should serve a self-corrective function that signals when procedures need modification. Moreover, daily behavior measurement enables teachers and therapists to meet demands for accountability.

**Continuous, Direct Recording and Measurement**

Applied behavior analysis evolved from the most sensitive system yet developed for quantifying what a behaver does under different environmental conditions.\(^ {355,363}\) Automated components force the laboratory analyst to design switches operable only by specific behaviors. Because there is no question of whether a movement cycle occurs or what form it takes, there is no problem of observer inaccuracy or disagreement. Antecedent and subsequent events are described precisely enough to be replicated by others, and their presentation is automatically scheduled and automatically recorded on the behaver's record.

The interaction of a behavior with its antecedent and subsequent events appears on a single graph, directly drawn by operations of an apparatus. These operations are recorded cumulatively through time, yielding integrated slopes that vary with the rate at which behavior occurs. Accounting for both time and number of responses, continuous rate measures provide information on how much the behaver did, how fast and how consistently. Furthermore, simultaneous rate recordings of two or more behaviors can reveal the functional relationships of "symptomatic" behaviors to reinforced operant behavior.\(^ {336}\)

These are the characteristics of measurement systems that show the subtle changes of early acquisition, the increase in rate at the beginning of extinction, the attenuating effects of satiation,\(^ {352}\) the temporal variations of behavior sustained by variously scheduled consequences\(^ {328}\) and the comparative effects of contingent, noncontingent and antecedent events on the emission of ongoing behavior.\(^ {18}\)

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When behavior analysis moves from highly controlled environments into field situations, some of its measurement precision is sacrificed. Behaviors chosen for analysis must be defined clearly enough for observers to be able to replicate them and to analyze the effectiveness of variations in a programmed workshop environment.\(^ {337,338}\) Workshops no longer have to limit their contracts to the menial tasks once thought to represent the upper limits of their clients' ability.\(^ {162}\)
definitions of behavioral and environmental events to be measured. Unless coupled with sensitive and reliable measurement, the coding effort will be unlikely to make results either identifiable or communicable. Moreover, without sensitive, reliable measurement, even the most rigorous evaluation designs, whether multiple baseline, multiple schedule, changing criterion or reversals, may yield irreproducible or inconclusive results.

Standardized Charting of Measured Behavior

Idiosyncrasies of data presentation need no longer confound communication. A universal measurement format now exists for summarizing and analyzing day-to-day behavior, whether it is time-sampled or continuously counted, whether it is measured as rate, latency, duration or frequency of episode onset. The chart, with an equal-ratio (logarithmic) ordinate, displays proportional changes in rate as equivalent whether they occur in high-rate behaviors or low-rate behaviors. The equal-interval, calendar-synchronized abscissa shows when behaviors were measured. Standardized plotting conventions permit graphic display of upper frequency limits imposed by recording procedure, elapsed recording time, duration of time when recorded behavior could occur and intermittency of recording. As a feedback source that makes visible these major dimensions of measurement sensitivity, no finer tool exists for their analysis.

AN OVERVIEW OF RESULTS: NEW HABILITATIVE OPPORTUNITIES

No longer attributed to low “intelligence” or other hypothetical causes, retarded behavior is being dramatically changed by environmental intervention. Although most applications incorporate various combinations and sequences of management and instructional contingencies, clear descriptions of procedures and desired outcomes enable many people to participate as behavior-change agents.

Augmented Habilitative Manpower

Parents are now viewed as critical agents in the behavior-change process. Early studies involved ongoing supervision and recording by professionals. However, later studies showed that, with minimal guid-

Continuous Recording and Measurement by an Observer

Recording devices can assist an observer in a field situation. With one such device an observer can record the frequency of onset and the durations of episodes of twelve different behaviors. With another, an observer can record the frequency of ten discrete behaviors as well as the onset and episode durations of ten others. The recording console can be separated into two units for independent recording by two observers. A light panel that signals when observers have disagreed can facilitate observer training. Although the graphic record is not drawn directly by the behaver's activity, these systems, like those of the automated environment, provide a permanent tracing of behavior occurrences throughout each session. Behavioral fluctuations within sessions are visible for later analysis.

Another versatile device allows recording of a student's responses to teacher-presented materials. Continuous recording of correct and incorrect responses shows which frames occasioned errors and therefore need revision, as well as how long each lesson took.

Continuous Counting with Summary Measurement

Portable recording devices are usually necessary in field situations. Golf score counters, supermarket price cumulators, abacus-type bead counters, tally cards or other devices permit easy totaling of discrete behaviors. With an ordinary clock or kitchen timer to give elapsed time, behavior rates can be calculated at the end of each recording period. Even though counting is continuous, only the total remains at the end of the counting period. As a result, fluctuations within periods are not known, but rate changes during successive periods are visible, especially when graphed.

If local rate must be sacrificed, counting periods should be as long as practicable, especially when behavior rates are variable. If, for example, a short counting period happens to be scheduled between episodes of high-rate behavior, the records will be misleading. In addition, the counting device should operate fast enough to track every occurrence of
the behavior under study; otherwise the resulting rates will be artifactually limited. If the counting device does not operate fast enough, counting episodes rather than every occurrence of a high-rate behavior may offer a compromise. However, a gross reduction in episode rate may not be accompanied by a similar reduction in rate within episodes. Few behaviors are emitted at a constant rate; fluctuations in behavior rates should be known in order to make the most sensitive selection of counting procedure.

Measurement sensitivity may be affected by the selection of target behavior, especially in low-functioning persons. If the recorded movement cycle is too complex, little progress will be shown unless the behavior unit is "sliced" into components. The child learning to walk, for example, will not appear to be progressing if the distance traveled per unit of time is measured, but the same child will likely show daily progress if the movement cycle is redefined as the number of steps per unit of time. Since the principal purpose of measurement is to provide feedback on the effectiveness of training or instruction, its message will directly reflect its sensitivity to the behavior components being acquired as prerequisite to composite task (target) performance.

Choice of summary measurement presents yet another potential communication filter for behavior. Even with appropriate behavior selection, continuous and permanent recording and reliable counting, summary quantification that neglects elapsed time will limit the yield of information. The most popular summary measure of pupil achievement is percent correct—a measure that wipes out a critical behavior dimension: time. Two individuals may achieve the ubiquitous 90%, but one may take five times as long as the other to do so. If both performances are quantified in the same way, some unfortunate decisions may result. Severely handicapped people can acquire normal accuracy levels, but their performance rates require specialized training. Measures which communicate only accuracy will result in less than satisfactory educational goals.

Intermittent Recording

Exigencies of the field situation and the nature of the behaviors under study may make continuous recording unfeasible. However, with time sampling and measures of observer agreement behavior-analytic methods can be applied to continuous behaviors in natural settings, as well as to multiple behaviors of individuals in groups. Requiring only brief observation during or at the end of each of a series of short time intervals, time sampling tallies the occurrence or nonoccurrence of specific behaviors. The procedure yields the percentage of intervals during which one or more behaviors occur. Observations of many behaviors of many persons can be scheduled by an interval timer.

Since the relationship of behavioral events to environmental events is the basic concern of behavior analysis, these events must be coded for rapid and accurate recording. Time-sampling methods, the derivation of coding systems, and measures of observer reliability have been described in detail. The usefulness of time sampling is illustrated by application to four categories of "disgusting" mealtime behaviors shown by institutional residents, to visual attending by pupils in a class for deaf children, to a variety of teacher and pupil behaviors in a classroom setting, to nine categories of "objectionable" behaviors of a child at home, to free play behaviors of autistic children and to oppositional and cooperative behaviors both at home and at school.

A comparison of different time-sampling procedures is especially useful for teachers who must shift their observation and recording from child to child throughout a classroom during periods scheduled for sampling. A variably scheduled sampling procedure that uses a classroom timer to signal observation periods and a recording form that shows successive timer settings allows systematic observations without constant attention to the task.

Different behaviors and environmental events occur at different rates, and behaviors fluctuate in frequency under different (often unidentified) conditions. Therefore the size of the time interval and the duration of each recording period should be empirically determined by preliminary continuous observation and recording of the behavioral and environmental events to be studied. The length of the recording interval should depend on the natural duration and frequency of behavior episodes as well as the duration and frequency of the antecedent and subsequent events that are to be analyzed as independent variables.

Insensitive time sampling may distort the recorded frequency of behaviors that occur intermittently. Pioneering field studies of institutionalized psychotic patients took behavior intermittency into account by having the nursing staff record patients' ongoing behavior every 30 minutes for 16 hours a day.

Time sampling cannot represent the true frequency of many behaviors because the size of the recording interval determines the upper limit, or "ceiling rate," of a given behavior. Thus, on-second intervals yield a maximum frequency of 6/min; five-second intervals reach a ceiling of 12/min. Interpretation of time-sampling data must avoid confusing a behavior ceiling with what may actually be an artifact of the recording procedure.

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Augmented Behavioral Repertoires

With potential habilitative personnel multiplied many times by a technology that enables “nonprofessionals” to serve as behavior-change agents, people with severely retarded behavior can acquire self-help, social, academic and vocational skills never before thought possible.

Self-help skills have been the most popular focus of training endeavors. Self-toileting is now readily taught; inexpensive training aids are available for those who wish to use them; mealtime behaviors are also readily taught, and social, academic and vocational skills never before thought possible.

Self-feeding and other appropriate mealtime behaviors are also readily taught, and technology that enables “nonprofessionals” to serve as behavior-change agents, people with severely retarded behavior can acquire self-help, so

Validated instructional sequences, based on years of research, are now commercially available for teaching eating,118 toothbrushing,190 nose blowing,198 complexion care,213 hair washing230 and hand washing.277 Because validation of these sequences was based on their use by non-professionals, and because the sequences have been published in inexpensive booklets, many persons with retarded behavior need no longer be totally dependent on caretakers.

Social and recreational skills can also be taught to disabled children when the immediate environment is appropriately arranged. Use of toys,271 219 254 402 social interaction,453 smiling behavior,397 appropriate smiling192 and cooperative play312 are examples of such skills that have been taught to “retarded” and “autistic” children.

Research on communication skills has been particularly extensive, and many excellent reviews and resources are available.146, 272, 233-235, 367 Two systems analyses that diagram sequences of component behavioral objectives in the training of receptive and productive language furnish guides for instruction and assessment of mute, inattentive, nonimitative, severely retarded children.80, 81, 170, 327 Objectives within the curricula can be organized as sequences of procedures specified precisely enough to be used by previously untrained instructors. A detailed language instruction program, first outlined in 1972, now includes instruction in gestural communication.254 Although criticized as stopping short of a useful level of language competence,170 this program, which first teaches attending behavior and imitation, is currently being used successfully by many whose previous efforts with severely low-functioning pupils had failed.

The receptive skills of instruction-following,392, 428, 439 including use of prepositions,136 and of comparative and superlative adjectives,24 have been successfully taught, and have the expressive use of plural nouns,168, 171, 326 generative past and present verb tenses,340 prepositions,328 questions,401 and sentences.147, 264, 424 Autistic children have new behaviors, the definition of a reinforceable response may be successively changed while discriminative and reinforcing stimuli are held constant. Alternatively, the functional response and its reinforcer may be held constant while antecedent events are successively changed until the behavior demonstrates its functions as discriminative stimuli. Once discriminated operants have been taught, the nature, frequency or timing of reinforcement can be varied to sustain or change their rates.

Just as movement cycles, antecedent events and subsequent events are operant components whose functions must be demonstrated, lesson plans, treatment plans and laboratory apparatus programs are operational descriptions of procedures performed by teachers, habilitators and laboratory investigators—working hypotheses that must be tested to determine their function. Whether microscopic or macroscopic, every component of the behavior-change environment remains hypothetical until its effect is shown by measured changes in the student’s behavior. It is the business of teachers, habilitators and laboratory investigators alike to evaluate their procedures. The effects, or functions, of instructional or habilitative procedures can be demonstrated only in measured behavior changes. To permit a behavior to communicate this critical information is the function of ongoing behavior measurement.

MEASUREMENT: THE BEHAVER’S MESSAGE

Especially in applications with severely disabled persons, whose behavioral changes may be both subtle and slow, the choice of a measurement system must be made with careful deliberation and full awareness of the sensitivity and clarity of its communication.156-157 The choice, in the final analysis, may be the choice of a “language” for people who do not speak. Therefore, in addition to arranging environments which maximize desirable behavior change, those who apply behavior analytic procedures must design measurement systems which maximize opportunities for a behavior to communicate. Sensitive, ongoing measurement of behavior as it relates to events in the habilitative/instructional environment provides an empirical basis for selecting and timing procedural changes, as well as for judging the effectiveness of the changes.68 The behavior changer who learns to use ongoing measurement finds powerful reinforcement in records that show successes often not revealed by unquantified observation—small changes that mark the beginning of acquisition, and the stability of performance that signals readiness for the next step. Equally important, the feedback of continuous measurement
which is a discriminated operant (a response maintained by a reinforcer and signaled by a stimulus). Each response in the sequence must become the stimulus for the succeeding response until the last response in the sequence produces a known reinforcer. Reliable performance of the entire chain is the instructional objective. However, absence of component links will result in failure. Procedures described earlier for response shaping, priming, building and strengthening as well as those for establishing the signaling (discriminative) function of antecedents may be applied to teach each of the missing components separately. Chaining sequences can then be applied to behaviors already in the trainee’s repertoire.

To maintain consistent immediate reinforcement for completing the sequence, many complicated behavior chains are taught backward. The last (reinforced) response is taught first, the next-to-last taught second, and so on. Thus the reinforced response remains constant while each of the preceding stimulus-response components becomes linked to all the others as the behaver executes them in appropriate forward sequence. Early applications of backward chaining taught severely retarded children to put on their pants and asocial chronic psychotic patients to engage in a “social” response and a token exchange to gain access to the dining room.

If a chain of behaviors is taught in the same order as required in final performance (forward chaining), the instructional environment must progressively change the criterion for a reinforceable response, much as in shaping, or else require step-by-step performance of the complete chain while gradually diminishing guidance or prompting throughout. An early example used forward chaining to prime the first instance of verbal imitation in nonimitative, mute, retarded children by first teaching the children to imitate a chain of motor responses and then adding a verbal component at the end of the motor chain. When the verbal components reached a close approximation of the trainer’s model, the motor components were successively eliminated until only the verbal imitation was performed. A recent publication presents validating data on a forward-chaining sequence that teaches toothbrushing.

Testing Procedural Assumptions by “Asking” the Behaver

This section has described methods for making movement cycles into functional responses and for converting antecedent events into stimuli which occasion certain responses. In an environment designed to teach learned to use compound sentences and severely retarded children have learned complete-sentence answers to questions. Procedures found to be successful in teaching two-way communicative sign language to a chimpanzee have been adapted to teach nonspeaking children to acquire gestural communication skills that appear to trigger vocalization in those with intact hearing. Methods for training chimpanzees to communicate via symbolic plastic shapes have been successfully adapted as a prosthetic nonspeech language medium for severely and profoundly retarded persons. An instruction program for its use is now commercially available.

Although generally assigned simple, repetitive tasks, persons with retarded behavior have acquired constructive vocational skills once considered beyond their capability. Commercial production of high-quality electromechanical components (including relay panels, signal and toggle switch panels and lead-mounted diodes) by moderately retarded institutional residents began in 1964. Severely retarded adults have been trained to use a drill press and recent research has shown that accurate assembly of 15-piece bicycle brakes and 52-piece cam switch actuators at competitive production rates can be taught to people once thought to be untrainable. Even profoundly retarded, deaf-blind persons are now acquiring such vocational skills.

Clearly, work opportunities for people with retarded behavior have been limited more by low expectancies and lack of methodologic sophistication on the part of supervisors and sponsors than by their clients’ deficiencies.

An instructive series of behavior-change projects shows how behavior-analytic methods may be used to answer questions germane to the design of more effective workshop environments. Particularly important is the demonstration that clients can be taught social and academic skills while they are performing contract-specified tasks without any loss in productivity. Dramatic advances in vocational training made possible by systematic application of research-based methods have been provocatively reviewed by Gold.

Assumptions about retardation have also limited the teaching of basic academic skills, crucial to social and vocational functioning in the community. Early applications of behavior management and programmed instruction procedures by Birnbrauer and his colleagues showed that skills such as reading, writing and arithmetic could be taught to institutionalized youngsters who had made little or no progress in other educational programs. And technology is now emerging to provide classroom instruction for severely low-functioning children herefore considered incapable of acquiring anything but the most rudimentary self-help skills.
Reading has traditionally been considered beyond the capabilities of students with test scores below the "educable" range. However, recent studies show that sight vocabulary and reading comprehension (of sentences as well as single words) are realistic instructional objectives for students with psychometric scores in the severely and profoundly retarded range. A valuable behavioral analysis of some basic reading skills furnishes not only well-defined instructional objectives and assessment procedures for each subskill but also a schema for detecting subskills that may emerge from various combinations of entering skills and instructional objectives.

That reading skills can serve in surprising ways is illustrated by a young institutionalized Down's syndrome student (PPVT below 12) with a history of rapid acquisition of receptive and expressive sight vocabulary. In our classroom, the child failed to acquire receptive comprehension of spatial prepositions until the various positions were labeled with appropriate printed words. After a few sessions, the labels were removed, and receptive comprehension of such words as inside and outside remained.

Math skills such as use of numerals, counting, adding and quantitative concepts obviously facilitate functioning in the community. Labeling numerals, writing numerals from dictation, selecting quantities of objects corresponding to numerals, adding printed numerals, telling time, using a ruler, using telephones, and counting out money to match price tags are examples of numerical and quantitative skills now being taught to people once considered only "trainable," "subtrainable" or "custodial." Although there is still little information on instructional procedures and optimally sequenced curricula for teaching math skills to severely retarded persons, sequences of skill-defined instructional objectives are under development. Successful mastery of the component prerequisite skills should make severely handicapped students eligible for more advanced training in coinage. Money value, use of recipes and other personal and domestic skills required in community living.

Handwriting, another skill once thought unattainable by people who score below a certain IQ range, is now being acquired by severely handicapped students. An instructional sequence being used successfully with preschool children may be a useful guide if modified to accommodate the entering skills of severely handicapped people. One carefully analyzed sequence progresses from prerequisite skills through visual discrimination of shapes, lines, letters, receptive letter recognition, tracing, copying and printing letters from dictation. In handwriting, as in reading and math, severely handicapped people have yet to show an upper limit or skill ceiling.

Instruction declines and the proportion of anticipatory responses—those dependent upon the auditory name—increases. Delaying presentation of a well-established stimulus following presentation of a "new" one converts the previously nonfunctional "new" event (namIng by trainer) into a discriminative stimulus. Previously "nonlistening" children thus learn to respond appropriately to oral instructions, thereby demonstrating that they have learned to listen. The procedure has also taught a variety of new instructions to severely handicapped students who had already acquired some limited instruction-following behavior.

Individualized stimulus functions. Because of the wide range of individual differences among handicapped children, whatever physical attributes of instructional materials function for a student as a signal for correct responding should be used in initial training—even if those attributes are unnecessary for final performance. Materials incorporating multiple "crutches" relevant attributes in the early phases of instruction will be useful with more students than materials incorporating only one "crutch" attribute. For example, one set of materials teaches severely retarded children to select printed words that match their spoken names. The correct word is printed in a different size and in a different color from the incorrect words. Further, the shape of each word is highlighted by a bright yellow background. The presence of three different "crutches" allows the same materials to be used with children who have already acquired either size or color or shape (configuration) discrimination. Transferring stimulus function from any of these cues to the uncued printed word is accomplished by fading out the redundant cues as instruction progresses.

Multiple cues permit testing (probing) the functions of each cue or combination of cues at various points in instruction to determine which are still necessary for a student. Such a program offers continuing diagnostic-prescriptive opportunities that should increase the efficiency of the teaching process by enabling students to use a greater variety of stimuli as initial acquisition "props." With highly selective autistic children, determining which antecedent events are functioning as stimuli may be critical for effective instruction.

Combining Discriminated Behaviors into Functional Sequences

Most adaptive behavior consists of sequences of responses each of which may be quite elemental. Dressing, toileting, bed-making, and the sequence of picking up, storing and exchanging tokens for preferred reinforcers exemplify complicated behavior chains, each component of
array and carefully developed sequences of fading, a "subtrainable" microcephalic man was taught to discriminate brightness from darkness, then presence from absence of a circle as the brightness difference was decreased, and finally circles from ellipses as "incorrect" stimuli (ellipses) were gradually faded in. As the ellipses were made more and more circular, continuing correct responding showed increasingly subtle discrimination. Continuous measurement of errors and successes throughout six preliminary versions revealed parts of the sequence that needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior.

A simple tabletop procedure gradually diminishes the distance of incorrect choices from the student until all choices are in horizontal array. This readily adaptable distance-fading procedure continues to be highly successful in rapidly teaching a wide variety of simultaneous visual discriminations to severely handicapped students. Stimulus transfer from visual to auditory events. Converting auditory events into functional instructional stimuli is an even greater problem with disabled children, many of whom appear "deaf" or have not learned to listen. As in the production of new responses, the process of converting antecedent events into stimuli must start with whatever behaviors and events are already functional for the individual. People who attend to visual events but who show no signs of listening may have no sensory impairment, but even with strong and well-programmed reinforcers, the auditory environment may continue to be nonfunctional unless the person's existing visual skills are brought to bear.

Progressively delayed presentation of established visual ("instructional") stimuli following presentation of auditory events can develop rapid transfer from visual to auditory stimuli. The delay procedure was first found to be effective in shifting a verbal labeling response from imitative control to control by objects and pictures (teaching a verbally imitative child to label parts of the instructional environment). It initially teaches imitative pointing to one of an array of colors as the trainer's pointing is paired with the instruction, "Point to __." When student pointing is reliably established, the instruction is given as usual on each trial but the visual event (trainer's pointing) is delayed four seconds to give the behaver a chance to show whether the auditory event (instruction) is functional. Gradually the proportion of "waits" for the visual array and carefully developed sequences of fading, a "subtrainable" microcephalic man was taught to discriminate brightness from darkness, then presence from absence of a circle as the brightness difference was decreased, and finally circles from ellipses as "incorrect" stimuli (ellipses) were gradually faded in. As the ellipses were made more and more circular, continuing correct responding showed increasingly subtle discrimination. Continuous measurement of errors and successes throughout six preliminary versions revealed parts of the sequence that needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior. The moment at which control of responding needed revision. The problems encountered en route to the final version and the changes that eliminated errors demonstrate the fine tuning of the antecedent instructional environment that can gradually convert useless events into stimuli—cues that can be used to teach more complicated discriminated behavior.

These are but a few examples of increasingly "normal" behavior being developed in people who until recently were denied educational opportunities because of deficiencies in the methods used to teach them and assumptions based on expectancies associated with low psychometric scores.

MAINTENANCE AND GENERALIZATION OF BEHAVIORAL GAINS

Evidence abounds that behaviors can be taught by appropriate arrangements of environmental events. But the usefulness of a behavior depends on the extent to which it allows the behaver to engage in "normal" social, academic and vocational activities. No matter how effective the teaching techniques or how sensitive and communicative the measurement system used for their evaluation, if newly taught skills are not visible in the behaver's repertoire, both credibility and cost-effectiveness may be questioned.

Maintenance of behavior after training, and generalization of newly taught behaviors to different tasks in different settings with different people present, are perhaps the greatest stumbling blocks in current behavioral habilitation. And these problems loom larger as more and more people are moved from institutions into the community.

Many procedures have been tested for effectiveness in sustaining behavior changes. Natural consequences—consequences commonly found in "normal" environments—have been systematically substituted for the contrived consequences (typically food or tokens) often used in training. For example, a smiling response that was originally taught with food reinforcement was eventually sustained by the reactions of others. Other procedures that have been tried with varying degrees of success are: peer praise for appropriate behavior; scheduling less frequent opportunities to use tokens for purchasing and thus gradually removing the training contingencies; equating stimulus conditions in the extra-treatment environment to correspond with those where behavior change was first achieved; training appropriate reactions in peers and training teachers in the use of contingencies; shifting to intermittent schedules of reinforcement more likely to be experienced in the natural environment; and including a number of people as change-agents.

Definitive information on this important problem remains sparse. Most successful treatment conditions may be composed of combinations of variables, each of which may be differentially effective for different individuals. In general, the highly structured environments found ef-
effective in producing behavior changes in severely handicapped persons do not exist in the "real" world. They are prosthetic environments where contingencies are systematic and controls are de rigueur—environments that facilitate acquisition by compensating for deficits. Ideally, gradual transition from the stringent programming necessary for acquisition to the less precise programming necessary for maintenance would enable the behaver to find sustenance in the "normal" world of endlessly varied settings and highly intermittent and usually intrinsic, social or monetary reinforcement. Otherwise the prosthetic conditions of training must be maintained by restructuring the post-treatment environment. Alternatively, a student's family can be taught to continue the treatment conditions in order to maintain treatment effects or parents can be taught to produce the effects themselves.

One might wish that entire communities could be re-educated to use behavior-supporting contingencies for the severely handicapped or even preventive contingencies that would obviate the need for radically different behavior-change environments. But such massive social change is unlikely in a world already overpopulated with individuals increasingly concerned about their own survival. As an alternative, prosthetic communities might be designed to teach and maintain acceptable and constructive activities among people with retarded behavior—communities conceptually similar to those designed for handicapped elderly people.

The extent of environmental prosthesis necessary to maintain and generalize treatment gains may be inversely related to the "unreality" of the treatment conditions. If so, gains obtained with minimal environmental change are more likely to be sensitive to "natural" contingencies and thus more readily maintained in the post-treatment environment than those obtained only in highly controlled and finely tuned—by definition "unnatural"—environments.

**Positive Indirect Behavior Control**

For the most part, behavior management has emphasized deceleration or elimination of undesirable behaviors. The focus on control has been attributed to the nature of problems referred by parents, institution staff and school personnel who have sought panaceas for disruptions in their own lives. Carried to their ultimate, decelerative management procedures can produce scenes of behavioral vegetation—wards, classrooms, homes where sitting quietly avoids aversive consequences for the troops and brings peace to the sergeants. The behavior control priority has been challenged as an unsuitable educational goal. It is especially but is really echolalic or echopraxic, a student who continues to count out objects after the requested number has been reached—such cases provide examples of behaviors that have been strengthened but not made responsive to appropriate environmental cues. To progress from behavioral deficiency to adaptive functioning, the student must be taught not only to engage in a variety of behaviors but to discriminate the appropriate conditions for each behavior.

While most normal children quickly learn when and when not to behave in certain ways simply by being told or shown, and many handicapped children learn simply through differential reinforcement, more specialized procedures are often necessary to teach discriminated behavior to severely disabled children. Studies cited earlier showed how gradual changes in the programming of successively presented antecedents could establish them as discriminative stimuli—cues which control the onset and cessation of specific behaviors. The component tasks in those cases consisted of performing an established response in the presence of a condition associated with reinforcement and pausing in the presence of a condition not associated with reinforcement. Responses in the presence of events not associated with reinforcement were defined as errors. Performance accuracy was determined by comparing the rates of behavior during the two conditions.

An early study showed that pigeons could acquire a successive discrimination without errors if the "wrong" conditions were faded in gradually as accurate responding persisted. A similar fading procedure taught preschool children the difficult task of discriminating simultaneously presented triangles that differed only in degree of rotation. The correct choice always appeared at full intensity while the two incorrect choices were at first invisible then gradually brightened until they were as bright as the correct choice. The brightness difference, which had served a prompting function, was then faded out until rotation was the only basis for correct choices. Fading was shown to be the major variable in establishing control of responding by the new visual cue.

Prompting and fading of prompts became a technology in its own right as programmed instruction sought to remedy the inefficiency of traditional pedagogical methods that permitted or even produced errors. But in programming instruction for severely disabled children, a new and persistent problem emerged: the antecedent events that could serve as prompts for pigeons and normal children were ineffective for many severely handicapped students. The problem was one of developing the stimulus functions of visual and auditory events that could then be used to increase the effectiveness of teaching methods.

**Visual event conversion.** With a simultaneously presented eight-choice
of behavior. And even if desired behavior elements do exist, arrangements that would strengthen and build upon them are often too time-consuming to be practical. However, in order that environmental events may be brought to bear, an acceptable movement cycle must be made to occur.

The first instance of a response can be built\textsuperscript{139} or primed\textsuperscript{144} by antecedent events that elicit the desired movement cycle. Then, by arranging systematic presentation of appropriate subsequent events, the primed movement cycle can be built into an operant response that is maintained by the consequences it produces.

"Putting through"\textsuperscript{218} or physically guiding complete execution of a movement cycle is a familiar way of priming the first instance. To prime hand-tapping or arm-lifting, a student’s hand or arm is guided through the movement cycle. The movement is immediately followed by a potentially reinforcing event. If that subsequent event functions as a reinforcer, the degree of guidance can be gradually diminished into prompts or “fragments of primes”\textsuperscript{204} and eventually eliminated as the new response comes under the control of its environmental effects.\textsuperscript{131, 132, 206}

For students with some receptive vocabulary, an instruction may serve as a prime that evokes the first instance. To prime hand-tapping or arm-lifting, a student’s hand or arm is guided through the movement cycle. The movement is immediately followed by a potentially reinforcing event. If that subsequent event functions as a reinforcer, the degree of guidance can be gradually diminished into prompts or “fragments of primes”\textsuperscript{204} and eventually eliminated as the new response comes under the control of its environmental effects.\textsuperscript{131, 132, 206}

Converting Antecedent Events into Stimuli

Arrangements that generate and strengthen new responses may produce behavioral deviance unless the new behaviors are made to occur only under appropriate circumstances. A child who appears to imitate questionable for clinical populations characterized by behavioral deficits and deficiencies. If not complemented by contingencies that strengthen adaptive and constructive alternative behaviors, decelerative behavior control risks eliminating the behaviors’ only effective means of manipulating their environments. The results may be not only counterproductive but also antithetical to the goal of behavioral normalization.

Contingencies that suppress self-stimulatory, self-destructive and hyperactive behaviors in children labeled retarded and autistic may have positive side effects such as facilitation of discrimination learning, increased spontaneous play, use of toys and initiation of contact with others.\textsuperscript{03, 216, 217, 257, 220, 407} but even in “normal” third graders, reduction of disrupting behaviors does not necessarily result in increased skill acquisition.\textsuperscript{119}

A more positive approach,\textsuperscript{418} and certainly a more defensible one, focuses on contingencies that strengthen specific alternative behaviors, with the “free” byproduct of simultaneously reducing “untreated” problematic behavior. Many studies have demonstrated reciprocal covariation of behaviors. For example, when reinforcement is delivered for clapping or rocking in time to music, or even pressing a bar, self-destructive behaviors may decelerate to near zero.\textsuperscript{221} When ball-pulling is systematically reinforced, rocking may disappear.\textsuperscript{188} Substantial reduction in the self-stimulatory activities of autistic children has been observed during discrimination training.\textsuperscript{216} A classroom program that reinforces only academic performances can eliminate undesirable behaviors\textsuperscript{16} and has been found as effective as drugs in controlling the behavior of hyperactive children.\textsuperscript{13}

Reciprocal covariation of positively and negatively valued behaviors is shown by deceleration of deviant behaviors as a side effect of strengthening constructive or adaptive behaviors. In severely handicapped children it appears that the more barren the repertoire of reinforced alternative behaviors, the more likely the development of deviant behaviors that produce effects from the environment. Conversely, the greater the frequency and range of positive alternative behaviors that produce reinforcement, the less likely the development of high-frequency deviant behaviors. The inverse relationship holds not only for individual behavior but also for groups of institutionalized children from differing residential climates.\textsuperscript{35} The educational value of focusing on behavior-strengthening contingencies is obvious. Early intervention programs that teach more normal behaviors to severely handicapped toddlers will likely demonstrate preventive functions as well. Among the very young children in one such program, it is difficult to find any behaviors that should be decelerated.\textsuperscript{79}
While both desirable and undesirable behaviors of severely low-functioning persons can be changed by altering their consequences, the effects are usually so highly situation-specific that they do not generalize to new settings or to people who have not been systematically involved in the behavior-change procedures unless such training is a planned part of treatment procedures. For this reason, contingency history, including the contingency-associated settings and people, is a salient "learner characteristic" that should become a thoroughly documented part of every problem-oriented educational record. Without such information, it is easy to assume mistakenly that behaviors emitted in a given environment represent the full repertoire of the behaver. Many previously acquired behaviors may not be emitted because of absence of antecedent or subsequent events that were highly discriminated components of the original instructional environment.

The problem for habilitators is, then, one of eliminating their own assumptions of behavior ceilings or limitations, detecting occurrences of appropriate actions and arranging behavior-accelerating consequences so as to require more functional, more adaptive emission rates. Because appropriate behaviors are generally incompatible with maladaptive behaviors, the more reactive the environment to positive, though initially low-frequency behaviors, the less likely it will generate or sustain behaviors considered to be deviant, bizarre or even retarded. Contingencies specifically designed to maintain and build upon positively valued socially, academically and vocationally relevant behaviors will, by both functional and operational definition, be those of a "normalizing" environment.

**Priorities for Alternative Behaviors**

One long-recognized facilitator of behavior maintenance is repeated use. Many skills disappear because they are not used. Ayllon and Azrin's rule of "relevancy" in selecting what to teach by behavior-change programming is a reminder of a familiar phenomenon: behaviors that are not reinforced in the natural environment will cease to be emitted. While "good behavior," "good sitting," "good looking" and other "on-task" postures may set the stage for instruction, as training objectives in their own right they are suspect—especially in a clinical population known for its dexterity and lack of self-initiative.

What, then, are some alternative behaviors? While self-help skills are a beginning, lowering of curriculum ceilings to accommodate constricted behavioral repertoires can no longer be justified. Behavioral limits are response that can be made to successively approximate a criterion behavior by gradual shifting of the requirement for a reinforceable response until the desired behavior is emitted. The procedure, called shaping, requires a previously demonstrated accelerating consequence and a previously established response. The response is then manipulated along whatever dimension brings it closer to the performance objective. Sensitive recognition of initially infrequent response approximations is required in order to shift the criteria for reinforcement appropriately. Especially with severely handicapped persons, the criteria for each successive approximation must be slowly advanced, always remaining within the range of movements being actively emitted by the behaver.

**Diminishing Antecedents: Prompts and Primes**

Rather than waiting for emission of an initial operant and relying on the shifting response criteria involved in shaping, a teacher can often speed up the acquisition process by successively changing the antecedents in the immediate environment to ensure execution of successively approximate behaviors.

For example, a motorically intact four-year-old would crawl toward and manipulate toys placed near her, but she had never walked. The height of the toys from the floor was gradually increased until the child had to stand to reach them. The horizontal distance of the toys from the child was increased to require her to take a step while using the table for support. Then the toys were placed on tables farther away, requiring the girl to take more steps to reach them. The sight of the toys functioned as a prompt discriminative for crawling, reinforced by manipulation of toys. Successively increasing the height and distance of the prompt required the child to engage in behaviors that successively approximated walking. Within only a few weeks, normal walking itself earned a variety of natural consequences that replaced the acquisition "crutches" of sequentially changing environmental conditions.

Similar methods of diminishing antecedent environmental "props" have been used to train a child with cerebral palsy to walk unassisted, a spina bifida child to use crutches and an autistic child to wear glasses after cataract surgery. Successively diminished completeness of verbal prompts is a familiar way of teaching articulation of polysyllabic words to persons with imitative skills. Fewer syllables are demonstrated on successive trials as the person is required to complete more of the word without help. The more quickly a prompt can be eliminated, the more rapidly will self-initiation occur.

Some severely impaired children may display few shapable fragments
scheduled the antecedent and subsequent conditions in the learning environment. But automation could not have produced reliable contingencies without devices that, by their design, precisely defined the behavior that could activate them and the conditions under which they could produce reinforcement.

In application, it is impossible to measure a student's progress or the effectiveness of instructional methods without a precise description of the behaviors to be taught and the conditions under which they should be engaged in. Especially in a handicapped population, one or more components of the instructional environment may be ineffective for a particular student. A quantifiable objective allows a student's behavior changes to reveal which modifications in an instructional environment contribute to acquisition.

The First Operant—Finding an Accelerating Consequence

To find a starting point, a student's behavioral repertoire is scrutinized for a rudimentary component of the final performance objective—a behavior that, if strengthened, will facilitate progress toward the instructional objective. Whatever the act, its operant function must be established by finding a subsequent event that, when repeatedly delivered contingent upon the behavior, will increase its rate. Examples of behaviors that could be selected for initial acceleration are: leg extensions that are necessary for walking, vocalizations that could eventually be differentiated into speech sounds, finger-thumb opposition that should eventually become grasping and pencil strokes that are components of letters. Bits of food, drops of milk and episodes of vibration are examples of subsequent events that may become accelerating consequences if delivered systematically and contingently.

The first operant is, then, the initial target of instruction as well as a vehicle for determining what subsequent events are effective accelerators for a given student.

Successively Changing Response Criteria: Shaping

Once the first operant is emitted reliably, its reinforcer is delivered selectively, contingent upon changes in the initial behavior that contribute to or are increasingly similar to the desired behavior. Successive changes in intensity, amplitude, latency, duration, accuracy and complexity illustrate behavioral dimensions of an operant response. This operant is now defined not by the student's psychometric score or medical diagnosis but by the teacher's skill in designing an effective instructional environment. Elementary skills of reading, writing and arithmetic are not only basic to community living but also offer entry into more "normal" public school curricula. Since the technology for teaching these skills to severely handicapped people is now emerging, their omission from curricula for this student group is no longer justifiable. Furthermore, since disruptive behaviors may be eliminated by strengthening academic skills, selection of functional academic target behaviors should produce a welcome byproduct. In contrast to treatment of behavior problems by short-term contingency management in prosthetic environments, the instructional gains developed with carefully planned longitudinal curricula may present fewer problems of maintenance and generalization.

Task-Analyzed Skill Hierarchies

Where to start and how to proceed are the most critical questions in designing instructional programs for people once considered "custodial." While the principles of programmed instruction and procedures for developing discriminations and behavior chains furnish leads on how to teach, they have not produced useful guides on what to teach and when to teach it. However, complementary procedures, developed from research on military training during the mid-fifties, conducted independently of the research on programming variables, are now being applied to help answer these questions.

Originally conceived as a way of determining optimal conditions for learning, task analysis begins with a behaviorally defined final performance objective and dissects it into its component skills. Working backward, the analysis continues to specify the prerequisites for the prerequisites until it reaches the most rudimentary skills that contribute to final performance. If properly executed, its product is a hierarchy of instructional objectives that starts with the subskills in a student's entering behavioral repertoire. The hierarchy specifies a sequence of instructional objectives that eventuates in the desired instructional outcome. In a well-analyzed sequence, mastery of each prerequisite skill should facilitate acquisition of the skill just above it in the hierarchy. Since every skill in the sequence is a component of or contributor to the skill above it, skills learned early in the sequence are, presumably, being used repeatedly and therefore should not disappear from the behaver's repertoire.
In addition to identifying the prerequisite skills for existing curricula, task analysis, like a carefully programmed instructional sequence, can help to identify both the existing and missing "enabling" skills of individual students. Backward analysis of sequential prerequisite instructional objectives, from those at the lower levels of existing curricula to those required for mastery of basic skills, should provide an instructional sequence that starts by teaching attending behaviors (tracking, scanning, listening, etc.) and simple component motor behaviors (touching, grasping, releasing, etc.), then moves the student upward through the skill hierarchy to the prerequisites for elementary public school curricula.

"Behavioralized" definition of instructional objectives, a popular indicator of "programming" sophistication, is a much needed step in the right direction. However, establishment of behavioral objectives, while necessary, is not sufficient. One has simply to review lists of objectives to realize that, although they may be finely task-analyzed statements of final performances expected under specific conditions, unless they are arranged sequentially in such a way that subordinate skills contribute to superordinate skills, they are little more than lists of splinter skills unrelated to the cumulative skill development expected from a hierarchically arranged curriculum. Instructional sequences that do not incorporate dependence of superordinate skills on previously learned subordinate skills may fail to maintain the skills learned in early stages. Work on task-analyzed curricula for early childhood education has been ably reviewed elsewhere. There is now an excellent task-analytically derived instructional hierarchy in early math skills that not only serves as a procedural model for extended study but provides a well-defined sequence of skill objectives from which only minor departures for severely handicapped people may be required. Component skills analysis and programming for severely disabled, low-functioning students illustrate the applicability of these techniques, originally developed to train military personnel to troubleshoot complicated electronic equipment—techniques that furnish guides on what skills to teach and when to teach them and, as an intrinsic byproduct, require continued use of component skills.

Mastery Criteria

An effective instructional hierarchy requires mastery of each prerequisite in the skill sequence. Specifying the behaviors to be performed and the conditions under which they are expected to occur as a result of

INSTRUCTIONAL CONTINGENCIES

Management contingencies may ease the jobs of parents, teachers and ward personnel, but they are not sufficient to expand the limited skill repertoires associated with behavioral retardation. While management contingencies often permit previously learned skills to re-emerge, severely low-functioning persons rarely acquire new skills without contingencies designed specifically for instruction.

Sequentially Changing Instructional Contingencies

Behavior analysis has been eminently successful in generating complex new skills in laboratory animals. Pigeons have been taught the concept of "human," as well as quality-control inspection of pharmaceutical capsules and diodes. Chimps have learned to use binary numbers to communicate via sign language and symbolic objects and to execute complicated behavioral sequences during flights in space capsules. Analysis of these and similar undertakings reveals many ingredients of successful instructional methodology. In all cases, new behaviors are synthesized from combinations of existing behaviors by sequential changes in the nature of the task requirements to produce reinforcement. Unlike stable management contingencies that address existing behaviors and alter their consequences for regulatory effects, instructional contingencies involve sequential changes in responses, in stimuli or in their increasingly complex relationships.

The behavior-generating sequences developed with laboratory animals found their analogs in the technology that became known as programmed instruction, which was first associated with "teaching machines." Systematic application to retarded behavior began in 1962 with a programmed curriculum and classroom token economy. Institutionalized children with severely and moderately retarded behavior acquired not only reading comprehension, writing and arithmetic skills but also the independent study skills expected of children their age (8 to 15 years) in community schools.

Defining the Outcome of Instruction

Clearly defined behavioral objectives, mandatory in the research from which programming technology was derived, are among the basic contributions of that research to education. Circuits automatically
instruction-following behavior. Teacher attention, contingent on instruction-following, was also effective. Attentive behaviors of 11 of 12 retarded children in a class were increased by the teacher's nonverbal approval but decreased when only verbal approval was given. Attention from peers may also function as an accelerating or decelerating consequence that influences teacher effectiveness.

Workshop productivity of multihandicapped clients has been increased by rate-contingent redeemable points by stepped-up production-rate criteria that must be met to avoid working in isolation and by production-contingent extra break-time. Analyses of task difficulty, schedules of reinforcement and production rates revealed that interactive effects of these factors must be taken into account in programming workshop pay schedules.

Children's academic response rates are also sensitive to operant contingencies. Oral reading rates of deaf children, scores of Down's syndrome children on a commercially available arithmetic sequence and picture-naming by severely retarded and "autistic" children can be increased with appropriate schedules of reinforcement. Moreover, standardized test scores, including IQs, can be increased by systematic reinforcement.

Temporal Dimensions and Terms

Management procedures are most generally applied to existing behaviors that occur at deficient or excessive rates or at inappropriate times. The environmental interventions involve changes in the nature or arrangement of subsequent events and often in the antecedent conditions present when the behavior occurs. To determine if a given arrangement is functional, a given set of operations must usually remain in effect throughout many recorded emissions of the target behavior (often over many days, weeks or, in some cases, months). Only then can appropriately designed analytic procedures be applied.

This domain of applied behavior analysis has many different labels. Contingency management is a general description of the procedures employed. Behavior management, behavior modification and, in some vernaculars, behavior therapy describe the outcomes (rather than the methodology per se) when procedures are used correctly. In any event, the procedures are directly derived from the experimental analysis of freely emitted behavior that changes in rate, duration or intensity as a result of its effect on the immediate environment (free operant behavior).

Instruction are recognized requirements of an adequately stated instructional objective. But a third requirement may be critical in the effective use of instructional hierarchies with handicapped people: the criteria by which mastery is measured. Mastery criteria are not likely to be uniform across different skill areas. However, for a clinical population known for its high intraindividual variability, stringent mastery criteria may be essential to ensure smooth progress from subordinate to superordinate skill objectives.

Mastery of an acquired skill means that the skill must be "immediately accessible" to the learner for use in acquiring the next skill in the hierarchy. The mastered skill is "performed with perfect confidence"—not just "sometimes." Stability or predictability of performance is, then, vital in defining skill mastery. In a well-designed hierarchy of instructional objectives, lack of mastery is expected to show up as "puzzlement, delay and inefficient trial and error" when the learner is instructed in the next superordinate skill. In contrast, the mastered skill shows positive "vertical" transfer by facilitating acquisition of the superordinate skill.

Skill mastery among severely handicapped people is usually not defined and more often confounded with criteria of acquisition, commonly designated in terms of individual performance at something less than 100% accuracy for a relatively small number of trials. Mastery is often assumed when minimal accuracy criteria have been met. The efficiency of an instructional tactic is often judged by the number of trials necessary to produce criterion performance. The rate at which accurate performance occurs is rarely considered, yet for a component skill to facilitate acquisition of more complicated skills, performance of the component must be rapid as well as accurate. Slow performance of a component skill may even prevent the student from reaching instructional objectives that depend on at least minimal rates of performance of "enabling" skills. Executing the chains of responses involved in writing numerals fast enough to be useful in elementary arithmetic instruction may depend on reaching acceptable rate criteria in drawing the stroke components of numerals. Likewise, reading comprehension may depend on a minimal rate of word labeling. And even at 100% accuracy, counting money and making change will not be functional skills—and therefore will not often be used—unless they are performed at rates suitable in, say, a supermarket or subway.

Contingencies that support acquisition are not those that strengthen or sustain behavior. Trial-by-trial presentation of materials, instructions and reinforcement for every "correct" response tend to produce a locked-in, teacher-determined pace that may persist even when
students present the same materials to themselves. Moreover, skills acquired with this instructional format are not likely to be self-initiated or performed independently. Certainly they should not be considered as "mastered" until these constraints are removed and the student performs them at more normally fluent rates. Since there is evidence that some institutional environments may foster low behavior rates, it is especially important to include fluency criteria in the instructional objectives of institutional residents.

Standardized procedures for obtaining fluency data are being developed and rate norms on basic preacademic and academic skills are being compiled. The relationship between fluency and skill transferability has not been systematically studied in severely handicapped people. However, it seems reasonable to expect that skills practiced at increasingly "normal" rates may be more useful and therefore more visible in the behaver's repertoire than those which are rate-limited by inadequately designed instructional materials and contingencies. There is evidence that contingencies which increase rate may, as a byproduct, also increase accuracy.

CONCLUDING COMMENTS

Behavior analysis has demonstrated fine control of the environmental variables that can make many behaviors normally accurate. To go beyond temporary prosthesis toward more permanent remedial effects will require use of more normal performance criteria by which to evaluate our instructional success with handicapped people. The behavior-change technology now being developed holds great promise for people once considered unable to learn—a promise that may be fulfilled only if we continue refining and sensitizing our methodology to maximize communication with those whose most articulate "voice" is their measured interaction with the environments we provide. Our problem is to pose them the most habilitatively relevant questions.

ACKNOWLEDGMENTS

My view of behavior analysis is both illuminated by and filtered through many years of research and development, seeded by a grant from the National Association for Retarded Citizens and patiently funded by the National Institute of Mental Health (grants MH-01354 and MH-14880). (I am primarily indebted to the many residents of the Walter E. Fernald State School who continue to show us what they can do if we provide them the opportunities.

My esteemed colleagues Judith Linn, Barbara Colby, Carl Binder and Eugene Buchman have greatly helped clarify many critical points.

view of punishment methodology is available. A comparison of different deceleration procedures and an analysis of punishment effects on multiple behaviors raise questions for further investigation. Excellent collections of articles on behavior management are available.

Accelerating Deficient Behaviors

The first documented application of behavior-analytic methods to a grossly deficient behavior was Fuller's demonstration in 1949 that arm movements by a profoundly retarded, crib-ridden teenager could be accelerated, eliminated and re-accelerated, depending on whether a few drops of warm sugar-milk were given immediately after each movement. Later studies showed that other motor behaviors respond as operants by increasing in frequency or duration when attention is given contingent upon the designated behavior and by decreasing when attention is withheld altogether or given only while the behavior is not occurring. Examples include the time spent on a climbing frame by a child with few motor skills and the time spent upright by a child who had reverted to crawling.

Social behaviors also respond to their effects on the immediate environment. A child's interactions with other children increased or decreased, depending on whether an adult's attention was provided while interactions were occurring. Selected behaviors involved in play interactions between two retarded children rose in frequency as the number of such behaviors necessary to produce candy and praise was successively increased. A chronically sad-looking institutionalized child smiled more often when smiling produced candy and less often when candy was not forthcoming. Then an ordinary personal greeting replaced candy as the consequence. The child's smiling increased when smiling yielded greetings and decreased when looking sad yielded greetings.

Intensity of verbalizations responded to an environment that required successively increasing intensity to produce reinforcement. An echolalic child's picture-naming increased in frequency when ice cream was given contingently and decreased when ice cream was randomly delivered. Rate of talking increased when the environment made talking worthwhile. Speech was reinstated in mute psychotics by an environment arranged to make speech pay off, and speech virtually disappeared when the environment responded to nonverbal behavior. Manipulation of standard differential token reinforcement contingencies, applied to all children in a class, produced increases and decreases in
may be an increase in the frequency of self-destructive acts.\textsuperscript{251, 260} When attention is withheld (extinction), self-destructive acts, like tantrums, eventually disappear.\textsuperscript{32, 260, 438} When attention accelerates more acceptable behaviors, self-destructive acts decelerate.\textsuperscript{4, 251, 300, 411} Conversely, when attention to more acceptable behaviors ceases, self-destructive behaviors return to their previous rates.\textsuperscript{251, 300} Elimination of social reinforcement may be slow and dangerous because the early stages of extinction are usually marked by temporarily increased frequency of the behavior being ignored ("frustration effect"). Brief periods of withdrawal from reinforcement (time out) contingent on each self-destructive act may be effective with relatively low-rate nonlethal behaviors,\textsuperscript{434} in which case reinforcement of nondestructive acts can take place concurrently. Continuous restraint not only precludes development of more appropriate behaviors but generally makes it impossible to analyze the role of specific environmental effects. Moreover, it may cause severe and irreversible physical deterioration. Systematic diminishing of restraint, concurrent with reinforcement of nondestructive behaviors, has often met with success.\textsuperscript{416a}

The fastest decelerator of self-destructive acts may be a momentarily painful electric shock delivered to the child's body contingent on each self-destructive act.\textsuperscript{92, 257, 260, 320, 387} A small number of shocks may eliminate the behavior in the treatment environment.\textsuperscript{173, 260, 320} The effect may even generalize to other environments, but the decelerative effects of shock often are situation specific. Nonetheless, if the self-destructive acts recur in new settings with unfamiliar people, a single shock usually suppresses the behavior.\textsuperscript{260} Other objectionable behaviors, though untreated, may disappear along with the dangerous acts,\textsuperscript{251} and only positive side effects have been observed.\textsuperscript{260, 320, 387} If shock delivery is systematically paired with "No"\textsuperscript{260} or another sound,\textsuperscript{387} that event alone can become a conditioned aversive stimulus which can be substituted for shock to further decelerate self-injurious behaviors.\textsuperscript{260, 320}

As soon as self-destructive behaviors are decelerated enough to introduce contingencies that accelerate more appropriate behaviors, the training that was previously impossible can proceed,\textsuperscript{251, 320, 387} thus providing the behaviors with alternative ways of affecting the environment without self-damage. However, if the post-treatment environment does not reinforce and further develop desirable behaviors, they will likely decelerate and previously established self-destructive behaviors may return.\textsuperscript{65, 255, 370}

Analyses of many high-frequency deviant behaviors and their successful management in wards, classrooms and home settings are ably reviewed elsewhere.\textsuperscript{66, 123, 131, 174, 201, 207, 209, 210, 285, 288, 320} An important re-

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the availability of reinforcement. A number of antecedent (setting) conditions are associated with high prevalence of apparently "spontaneous" stereotypy among groups in institutions, and they are well reviewed elsewhere. 47 Some persons acquire rocking simply by imitating their wardmates. Furthermore, repetitive stereotyped behaviors, if they are not disruptive, may produce little or no social reaction. Therefore, unlike high-frequency behaviors that do produce reinforcing reactions, some self-stimulatory behaviors cannot be decelerated simply by withholding attention. Extinction, as a deceleration procedure, requires that the behavior-maintaining reinforcer be known.

In some persons, rocking, like the pacing of psychotic patients, may continue unabated while they perform other behaviors sustained by their environmental effects. However, long-term, simultaneous recording of both rocking and a systematically reinforced manual task suggests that, while an alternative behavior is being differentially reinforced, rocking may disappear without direct intervention. Thus, some repetitive self-stimulatory behaviors appear to be incompatible with behaviors that are being reinforced by the environment, or when reinforcement is delivered for more acceptable forms of behavior. When the environment ceases to react to the adaptive alternative behavior, stereotyped behaviors return.

Some high-rate stereotypies appear to require contingencies that directly eliminate or reduce their frequency before the behavior can acquire more acceptable ways of interacting with the environment. Repetitive behaviors, including minor motor seizures, have been decelerated by contingent shouting ("Stop that!") coupled with bodily shaking, "No!" plus a slap on the thigh or contingent enforced practice of an alternative behavior. Momentary electric shock delivered to the body contingent upon every occurrence of the stereotyped movement may be effective when a behavior occurs at such high rates that it is difficult to reinforce alternative behaviors without risk of inadvertently accelerat-

Self-destructive behaviors also appear to be stereotyped. However, when the reactions they evoke make their operant function apparent. When observers react with sympathetic comments or physical attention, the result
Decelerating Excessive Behaviors

That many "symptomatic" behaviors have operant function has been demonstrated by analyses of their functional relationship to environmental events. For example, the frequency of stuttering decreased when every occurrence was punished with a blast of noise, and rose when every occurrence was negatively reinforced by escape from noise. Moreover, normally fluent persons acquired stuttering when every occurrence of nonfluent reading was negatively reinforced by escape from aversive conditions. The frequency of neurogenic multiple body tics decreased dramatically when every occurrence interrupted music the tiqueur had chosen to listen to. The duration of bedtime crying increased when the behavior earned a parent's bedside attention for longer and longer intervals, but episodes of crying ceased by the tenth time the child was put to bed and left alone (extinction). An obese woman stopped stealing food when every occurrence of stealing resulted in her being removed from the dining room (withdrawal of reinforcement), and she stopped hoarding towels when ward staff systematically dispensed some 600 of them over a four-week period (satiation). She also stopped wearing multiple layers of clothing (average 25 lb.) when access to meals was made contingent on her removing more and more superfluous garments (reinforcement of incompatible behavior). These and many other investigations have shown that appropriate changes in environmental reactions can control the occurrence of excessive behaviors.

Stereotyped rocking, like "compulsive" broom-holding by a psychotic patient and headbanging by monkeys, can be generated by the same procedures that are effective with more adaptive behaviors. Whether produced experimentally or acquired "spontaneously," rocking shows the same functional relationships to schedules of reinforcement as other forms of operant behavior. Moreover, rocking can become a discriminated operant that occurs only in the presence of stimuli that signal
then eliminated simply by careful scheduling of selected reactions by the staff. 178

From demonstrations of individual behavior change, the procedures were extended to manage specific behaviors of all residents in a hospital ward. First food was made contingent on arrival at the dining room within a time period that was progressively shortened until residents appeared on time and ate without cajoling, tube feeding or other forms of attention previously given the unwanted behaviors. Access to food was then used as a consequence for other behaviors. 10

Starting in 1961, metal tokens were introduced as payment for certain off-ward jobs, routine ward maintenance and self-care. Ward residents could use the tokens to purchase items and privileges. Analyses of the behavioral effects of token contingencies, descriptions of behaviors that earned tokens, the privileges that could be purchased 9 and the detailed training program that was developed from them 9 are landmarks in the literature on human behavior management that should be studied by all potential practitioners.

The model that was developed for state hospital ward management 7,9 was later adapted for use in training schools 58, 208 and a classroom for institutionalized retarded children. 67, 69, 71

Long reference lists and many excellent critical and instructive reviews attest to the popularity of the token economy in applied behavior analysis. 4, 9, 208, 209, 288 However, most studies have involved groups who have already acquired the numerical skills that are essential to economic transactions.

The Management and Instructional Domains

Experimental adaptations of animal conditioning methods to human behavior demonstrated the feasibility of applying the methodology to a wide range of behaviors in a wide variety of settings. 66, 273

Applications to problematic behaviors evolved into two closely interrelated domains. Behavior management alters existing deviant or deficient behaviors by modifying their consequences and maintaining stable contingencies until desired behaviors are reliably demonstrated. Programmed instruction develops new behaviors by sequentially changing the nature and complexity of responses and their relationship to increasingly complex stimuli. The following two sections describe some of the important contributions that have broadened the applicability of these habilitative methodologies to include the most severely “disturbed” and behaviorally deficient persons.
telling. In another study, six of 12 "learning disabled" children revealed listening deficits; only one showed normal looking and listening patterns. Instruction of such children might be made more effective through analysis of patterns of attending to varieties of auditory and visual material.

Behavior-analytic crib environments. Other adaptations of the behavior-analytic environment have located behavior-generating and sustaining events for profoundly disabled crib-ridden youngsters. With additional modifications, multiply handicapped children have been taught to match movement topographies to specific auditory consequences. Still other environmental designs have enabled infant panel-kicking patterns to show that the sight of a smiling adult is a behavior-generating consequence.

These exploratory analyses showed that behavior-analytic methodology was, indeed, applicable to the assessment and habilitation of severely disordered and deficient behavior. With continuously recorded behavior in suitably designed environments, questions are asked by different arrangements of environmental events. Answers are provided by directly measured changes in behavior that show whether particular modifications are functional in altering or sustaining an individual's behavior. Observer biases and recording errors are bypassed, and the behaver's automatically recorded actions become an objective medium of communication. However, for broader applicability, field treatment situations demand that the function of other individuals in the environment be analyzed.

Behavior-Analytic Group Environments

That people's reactions can generate and sustain as well as reduce or eliminate behavior was first clearly demonstrated by application of behavior-analytic procedures to ward management. Starting in the late 1950s a series of demonstrations by Ayllon and his colleagues showed that deviant behaviors could be reduced in frequency and often eliminated by explicit, systematic changes in the reactions of ward personnel. Although nurse-reaction contingencies were in effect 24 hours a day, specific behavior changes in individual patients took 6 to 11 weeks to emerge. Behaviors included "psychotic talk"; refusal to self-feed; stealing food; hoarding rubbish, magazines and towels; and wearing excessive clothing. Moreover, a stereotyped behavior (interpreted psychodynamically as "magical, phallic, omnipotent, compulsive, symbolic of wish fulfillment") was generated, maintained and...
143. Gagne, R. M.: Task analysis—its may not affect the rate at which accurate performance occurs. Procedures that build rate of accurate performance appear to be critical for the more severely retarded, for those who are younger at admission and younger at the time training starts.
144. Sensory acuity. Still other adaptations of the behavior analytic environment can reveal sensory impairments as distinct from lack of basic discrimination skills. In one early study,78 children learned to make one response in the presence of one lighted panel and another response in the presence of another lighted panel. Then pure tones of varying frequencies, at an intensity level above normal threshold, were paired with only one of the lights. Trinkets and candies were made available only when the child pulled the "correct" plunger during the light-tone condition. Gradually, as the lights were faded out, the tones came to control responding and their intensity was decreased until the child's performance indicated inability to hear the tone.
145. Other operant audiometry procedures have used a single response button and offered projected slides74 or trinkets and candy76 for responding in the presence of a tone but not for responding in its absence. One sequence pretrained severely low functioning children to discriminate the presence of a light, then paired a tone with the light.80 The signal for responding was gradually shifted from the light to the tone, and then the intensity of the tone was gradually decreased until the children demonstrated inability to hear by failing to make use of the auditory antecedent.
146. Similarly, behavior-analytic procedures have been used to estimate the visual acuity of nonverbal children.265 Barpressing in the presence of an illuminated panel produced candy, cereal or pretzels, while pressing in its absence produced nothing. As children acquired the light-no light discrimination, E's and reversed E's (comparable to those on a Snellen chart) were gradually substituted for the lighted and unlighted panels respectively. Visual acuity was estimated on the basis of accurate responding to E's of various sizes and at various distances from the child.
147. Modality preferences. Variations in the behavior-analytic environment have given more precise information about individual auditory preferences266 and about individual preferences for visual versus auditory stimuli.277 An arrangement whereby intensity of a continuously available stimulus varies as a function of response rate (conjugate scheduling) enables a person to indicate preference for ongoing visual or auditory scenarios. The "listening" patterns (both working to listen and stopping to listen) of moderately retarded community school children revealed uniform rejection of normal speech rates (180 words/min.) and preference for both slower-than-normal and faster-than-normal rates of story-
Extending the Environment's Functional Descriptive and Assessment Capabilities

Basic behavior characteristics. Sensitive paced manipulation of environmental contingencies can produce rapid change toward normality. On the other hand, a constant environment, offering a variety of ways to obtain reinforcement, permits individually different patterns—both defective and "normal"—to emerge. Such an arrangement permits behavioral retardation to be functionally defined in terms of responses to constant screening contingencies. Subsequent analyses may show differential effects of remedial procedures.

One such environment, designed to measure response differentiation and stimulus discrimination separately, permitted highly individualized behavioral patterns to emerge. Participants showed stereotypies, variable as well as normal patterns of behavior.

The six patterns of behavioral accuracy and deficit ranged from "normal" to severely deficient, but were not associated with psychometric classification, diagnosis, sex, age, duration of institutionalization or age at admission. At no stage during the course of acquisition was psychometric classification predictive of the way participants distributed themselves in the functionally defined accuracy/deficit categories. However, those classified as more severely retarded required significantly more time in the conditioning environment to show which contingencies were functional for them. Throughout the course of acquisition, the more severely retarded consistently operated the apparatus at lower rates than those who were less retarded. Lower rates were also associated with lower age and younger ages at time of admission to the institution.

Psychometrically associated rate differences were also shown when each participant was working for whatever consequence sustained his or her highest rates, whether candies and pennies, the video channel of TV when audio was "free," colored slides, recorded music or the audio channel of TV when the video was "free." But differences in the ward environments where residents live may override psychometric attributes in contributing to rate differences.

Analysis of defective components in the experimental environment shows that the emergent deficit patterns are differentially diagnostic of the nature of environmental change that produces more "normal" patterns of responding. While manipulations of this environment can produce acquisition in the majority of even the most severely retarded persons, the contingencies sufficient to produce more accurate performance to content analysis. Educational Psychologist 11: 11-18, 1974.


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often associated with episodes of symptomatic behaviors that interfere with reinforced operant behavior.233,234,236

Nonetheless, these studies demonstrated that properly selected, intermittently scheduled consequences could sustain human behavior for long-term analysis. To reveal habitually relevant individual characteristics, this capability became a methodologic necessity because of the temporal variability of disordered behavior, the wide range of individual differences in acquisition times, and the widely varying rates that distinguished one patient from another. Consequence-sustained behavior was demonstrated to be sensitive to the effects of drugs,231,233,235 to the effects of psychotherapy,233,238 to therapeutic interview variables,242 to changes in circumstances of daily living within the hospital,231 and to specific behavior deficits,233,234 and was correlated with clinical behavior ratings.274 With the laboratory prototypes of today's multiple baseline analyses,28 it was possible to monitor recovery,224 to determine the differential effects of drugs on both symptomatic and adjunctive behaviors,234 and to provide consequences contingent upon symptom emission,232,233

The first studies of retarded behavior demonstrated lawful relationships to different reinforcement schedules and illustrated the range of rates and differences in rate patterns shown by selected institutional residents during a relatively small number of sessions in a conditioning enclosure.115,292 Variations in the environment were analyzed for their effects in facilitating discrimination290,291—the first diagnostic-prescriptive application of free operant behavior analysis to determine which environmental events are functional for which persons.

Ferster and DeMyer extended the methodology to analyze the behavior of autistic children—another clinical population whose behavioral variability and individual differences in acquisition times necessitated long-term analysis.125,126 In addition to food and candy dispensers, a headset for listening to music, a trained pigeon in a box, a kaleidoscope, a pinball machine, a television set, an enclosed electric train, a slide viewer and other devices were gradually incorporated into the fully automated environment. Children learned to press a key to obtain intermittently available tokens, which could then be inserted in slots to operate devices of the child's choice. This procedure developed a durable conditioned reinforcer (token). The 60- to 90-minute daily sessions of keypressing behavior sustained in this manner eventually showed schedule-related patterns similar to those shown by laboratory animals.

When the children's behavior stabilized, the investigators varied the environmental antecedents to require more complex behaviors. Both

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Methodologic Refinements for Human Behavior

Relying largely on arrangements of subsequent events with respect to an individual's ongoing motor behavior, the methodology developed for animal behavior analysis is particularly suitable for analysis of those human behaviors for which no reliable eliciting events can be found. Further, because it does not require verbal communication, the methodology is applicable to persons whose verbal skills are disordered or deficient.

Applications to human behavior began in 1953 with Lindsley's adaptations of laboratory environments for analysis of chronic psychotic behavior.244 365 While the environmental programming and behavior recording functions and the investigative design remained unchanged from the analysis of animal behavior, the environment was modified to withstand assaultive behavior while continuously recording the rates of both adaptive and symptomatic behaviors.331 233

As with later applications, there were two basic methodologic problems: defining the behaviors to be analyzed and discovering consequences that would sustain behaviors in people considered to be "out of contact" with or unresponsive to normal environments. Uniform behavior definition with continuous, direct measurement was achieved by design of a durable plunger manipulation that operated automatic recording and programming equipment each time it was pulled231 or pushed.231 "Symptomatic" vocal and motor behaviors were respectively defined by a voice-operated relay222 and by pressure-sensitive electromechanical floor mats.234 As in the case of the key that pigeons peck to obtain food,128 these devices were operated by movements already in most persons' repertoire—an illustration of a basic principle of behavior analysis: begin with what the behavior does.

Studies of the behavior-sustaining function of intermittently scheduled subsequent events revealed extreme individual differences in rates of behavior that could produce candies, cigarettes, nickels, projected slides of nude, short periods of music, or opportunities to watch a hungry kiten being fed.231 237 While candies were effective consequences for some patients with chronically psychotic behavior, money was more effective with acutely psychotic persons and with those improving prior to discharge.234 Some patients took over a year of daily sessions to show rate increases, and there were others for whom none of the available subsequent events and arrangements generated useful behavior rates.233

The most prevalent characteristic of psychotic behavior revealed by Lindsley's long-term studies was variability—fluctuations in hour-to-hour and day-to-day rates that varied widely from person to person and were...
habilitating environment. While considered by some to be a radical departure from more traditional views of treatment, the methods and principles of behavior analysis are based on decades of research on both animal and human behavior.

THE GROUNDWORK

Behavior analysis originated in studies of laboratory animals. In the late 1800s Pavlov, studying the digestive system of dogs, found that salivation, normally elicited by presentation of food, was lawfully elicited by other antecedent events that had been systematically presented with food. At about the same time, Thorndike found that hungry cats took less and less time to escape from a "puzzle box" when escape led to food. The relationship between a cat's behavior and its environmental consequences was elaborated into the well-known law of effect.

But the impact of environmental events on behavior did not become fully evident until Skinner devised an experimental space in which an animal could freely obtain food pellets by depressing a bar. If food was made available only intermittently, barpressing could be sustained for long-term study. It could be accelerated, decelerated or made more complex depending on what the environmental design required the animal to do to get food. Ongoing behavior, uninterrupted by experimenter-controlled trials, was directly and automatically recorded in cumulative tracings that showed both the immediate and the long-term effects of variations in an animal's immediate environment. With methods paralleling those of experimental medicine, conclusive experiments could be performed on single organisms without recourse to statistically designed group studies.

As Watson had foretold, behavior emerged as a subject in its own right—freed from mentalistic interpretations and described by the environmental operations demonstrably responsible for its change.

In 1953 Skinner articulated the advantages of rate or frequency of response as a basic datum, and he described the predictable patterns of behavior produced by different frequency and timing of environmental consequences (schedules of reinforcement). Highlights of his methodologic inventions were described in a 1956 paper. Application of carefully programmed consequences to animal instruction was engagingly described in 1951. Since then, studies of many species of organisms have continued to show that, if environmental events are carefully arranged in relation to well-defined behavioral acts, predictable and often complex patterns of behavior emerge.


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294. Panayi, M. C.: New Ways to Behaviors in "retarded" persons. Arrangements that have not been modified to be functional acquisition contingencies for handicapped people will fail to generate new skills. Moreover, skills already acquired may never be performed at "normal" rates if the contingencies that facilitated acquisition are not modified to accelerate and sustain their speed. If effective consequences are made available regardless of what the behavior is doing (noncontingently), skills will likely disappear and be replaced by whatever nonadaptive behaviors are being engaged in at the time the consequences are delivered. Proper design of behavior-dependent contingencies is critical in determining the success of behavior-analytic methods in habituating retarded behavior.

Defining the Focus of Intervention

Many events may occur before and during a movement cycle, and a host of environmental reactions may follow. Still, some behaviors may appear to occur irrespective of antecedent events and may even appear to produce no reaction. The first business of behavior analysis is to determine which observable aspects of the environment a person is interacting with. Behavior analysis begins with an operational description of what the person is doing or is supposed to do, the conditions that should or may serve as initiating signals for the behavior, the observable changes in the environment following the behavior, and how often and when these environmental reactions occur. It then proceeds to determine the functionality of each physical component by systematically changing one at a time and observing the effect of every change on the measured frequency of the selected behavior. This is the basic methodology of experimental control derived from laboratory behavior analysis.239 - 243

Identification of a defective component for a given person in a given environment constitutes behavioral "diagnosis." A defective component is one that is not currently functional in relation to the desired behavior, or one that is supporting an undesirable behavior. Manipulation of various parameters of a defective environmental component until its measured effect demonstrates the desired function for the desired behavior is the process of behavior-analytic habilitation. The environment is modified until the appropriate behavior-generative and behavior-supportive effects are shown in measured and durable behavior change.

Failures in applying behavior-analytic methods are, then, attributable not to hypothetical learner characteristics such as "intelligence," "defective ego strength" or "brain damage," but to inadequate design of a
nouncements ("Dinner is ready"), being placed on the toilet—these are examples of antecedent events intended to signal the occurrence of certain behaviors. But antecedent events, whether deliberately arranged or naturally occurring, cannot be assumed to serve stimulus functions until they reliably evoke the appropriate behavior.

Developing the stimulus functions of antecedents is basic to the instructional process with handicapped people. The child who does not attend to visual events and the child who has not yet learned to listen are not teaching attendants the applied aspects of behavior modification. Ment. Retard. 5(12): 30-32, 1974.


The environment may not react to every occurrence of a behavior. Most behaviors produce only intermittent environmental change. In the context of behavior-environment interaction, an arrangement describes what the environment requires of the behaver before it reacts. An arrangement is, then, a behavior-dependent schedule of environmental reaction.

Research has shown repeatedly that an arrangement providing a demonstrated positive consequence (reinforcer) every time a response occurs is most effective for generating a new behavior. However, once a behavior has been taught, it is more likely to be sustained in the behaver's repertoire if the arrangement is made more intermittent—scheduling that sustains most "normal" behavior. For example, a positive consequence may be delivered after a fixed or varying number of responses has occurred, or it may be made available at regular or varying time intervals if at least one response has occurred. Each type of arrangement produces its own distinctive pattern of sustained responding.128

If an already functional response varies in frequency with different arrangements of an already functional consequence, the arrangements are functioning as contingencies. Like other manipulable components of behavior-environment interaction, the contingent relationship between a particular behavior and its consequences may be deliberately arranged in an effort to change behavior. While the predominantly intermittent schedules of the "normal" environment may function as adequate contingencies for "normal" behavior development, such arrangements may not be functional contingencies for developing more competent be-
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variables are behavioral events and environmental events. Because they are observable and measurable, their interactive effects can be studied with the objective, systematic methods of scientific inquiry.\(^{117,130,205,221,340,404}\)

Although a person's activities within an environment are continuous, dynamic and often complex, the basic ingredients can be described in terms of physical (operational) and functional components. The operationally defined components of ongoing behavior in a given environment are called antecedent events, movement cycles, arrangements and subsequent events.\(^{239}\) If directly measured behavioral changes reveal a functional relationship, or interaction, among these components, their more familiar designations apply: stimulus, response, contingency and consequence. The distinction is critical in analyses of retarded behavior, which often fails to show expected, or "normal," interactions with the recognized events of a "normal" environment.

Movement Cycles: Potential Responses

Behavior analysis requires that its subject matter be measured. Therefore it focuses on what a person does—acts or sequences of acts described precisely enough for independent observers to agree on their occurrences. To account for the dynamics of behavior-environment interaction, behavior analysis further requires that acts be repeatable movement cycles with discernible beginnings and ends.\(^{128}\) Each movement cycle consists of an act with respect to an object, e.g., raising one's arm,\(^{137}\) rocking one's body,\(^{188-190}\) banging one's head,\(^{260}\) assembling bicycle brakes.\(^{161}\)

Almost all persons with retarded behavior engage in various movements, many of which can be converted into functional responses that produce something from the immediate environment. If a movement cycle increases in frequency when repeatedly followed by an appropriate environmental event, it becomes a functional response. Movement cycles that fail to change the environment may drop out of the behaver's repertoire. Those that produce positive environmental events for the behaver will be accelerated even though the behavior may be objectionable to others. The variety of behaviors in a person's repertoire may depend largely on whether the environment has regularly reacted in a way that makes those behaviors functional for the behaver. Analyses of retarded behavior have shown that objectionable movement cycles often become functional responses while more desirable movement cycles do not develop into functional responses because they do not systematically produce environmental reactions.\(^{256,121,122}\)

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INTRODUCTION

New opportunities for behavioral competence are becoming increasingly available to people once considered subtrainable and consigned to private attics, church basements or the restrictive wards of state institutions. Behavior-analytic methods are producing dramatic changes in such people regardless of the etiology, severity or chronicity of their handicap, or their age, psychometric classification, socioeconomic status and other factors once thought to determine their "trainability."

This chapter describes the ingredients of behavior analysis. It sketches some highlights of the experimental origins of current applications, and it presents some of the refinements that most directly affect the habilitation of severely retarded behavior. Finally, it outlines some of the important results and suggests some directions for future development.

Neither a how-to manual nor a comprehensive review of the literature, its purpose is to provide some perspective for those who wish to become familiar with the current range of behavior-analytic endeavors on behalf of severely handicapped people. Those who seek more detailed procedural information will find ample references for further study.

WHAT IS BEHAVIOR ANALYSIS?

Behavior analysis is a methodology that identifies and manipulates environmental conditions that are actively affecting a person's behavior. Its


Behavior Analysis

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