# DIRECT MEASUREMENT AND PROSTHESIS OF RETARDED BEHAVIOR<sup>1,2</sup>

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Children are not retarded. Only their *behavior* in average environments is sometimes retarded. In fact, it is modern science's ability to design suitable environments for these children that is retarded. We design environments to maintain life, but not to maintain dignified behavior. The purpose of this paper is to suggest techniques of designing *prosthetic* environments for maximizing the behavioral efficiency of exceptional children who show deficits when forced to behave in average environments.<sup>4</sup> These suggestions evolved from the methods and discoveries of free-operant conditioning.

In order to design a suitable environment for the behavior of a given individual, it is necessary to specify the individual's behavioral potential in the most precise, detailed terms possible. *Direct measurement* means automatically recording a time sample of behavior in a controlled and specified environment. With direct measurement, no problems of observer bias or test validity occur; everyone admits that the behavior of concern has been directly recorded. Questions still remain concerning the reliability of the recording, the adequacy of the sample duration, and interaction between the recording system and the behavior being sampled. However, these questions can be adequately answered by manipulating variables within the behavior laboratory and by the accuracy of prediction.

Even behavioral processes which do not directly act upon some aspect of the environment or do not consist of a specified movement can be made available for relatively direct measurement. An easily recorded, arbitrary movement such as lever-pressing can be inserted between the individual and that aspect of the environment he is attending to. We call this "externalizing the be havior." It is useful if the externalizing response has minimal behavioral effects of its own (e.g., fatigue, satiation, intrinsic reinforcement).

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<sup>3</sup> I have recently suggested prosthetic environments for the aged (Lindsley, 1964a). Many devices suitable for prosthetizing geriatric behavior will also be useful for certain types of retarded behavior.

In the early days of environmental therapy (viz.: psychotherapy; group, milieu, and occupational therapy), although there were few objective data, therapists argued for their procedures with poor but highly successful logic. They suggested that the cause or nature of the deficits was similar to the type of therapy. Psychotherapists argued strongly for environmental causation of mental illness in order to justify their environmental treatments. Neurologists, biochemists, and pathologists argued strongly for organic causation of behavioral disorders in order to justify their organic treatments. This primitive homeopathic argument that "like is cured by like," once widely accepted in medicine', has been proven false for physiological disease.

Homeopathic psychiatry, however, is still maintained by many therapeutic partisans as they suggest their cures for behavioral disorders. This fallacious argument placed the individual with retarded behavior at the bottom of the list for environmental treatment, since the case was strong that his behavioral deficits were organically caused.

Just as homeopathic organic medicine was disproved in the first half of the twentieth century, so will homeopathic behavioral medicine be disproved in the second half. Recent research has suggested that patients with organic myoclonus respond more rapidly to environmental reinforcement for not ticing than do patients with tics of neurotic origin (Barrett, 1962). Our own research has shown less intermittency of behavioral emission (implying less attention disorder) in retarded adults and children than in psychotic individuals (Lindsley, 1958, 1960, 1962). Others have suggested that organic etiology is no indication that a disorder will not respond to environmental therapy (Zubin, 1963). This may be because environmentally caused behavioral disorders involve the major portion of the behaving system of the individual and the input channels are thus "jammed" by psychotic symptoms. Symptoms appear to dominate a psychotic person's behavior and are stronger than most discriminative and reinforcing stimuli that the environmental engineer can produce. Someone who is busy being sick is much harder to stimulate than someone who is born with a limited behavioral repertoire. Environmental treatment may prove to be the treatment of choice for retarded behavior, even when of organic origin.

# Deficiency-Produced Specific Superiority

Environmental prosthesis might not only neutralize the deficits of the behaviorally handicapped but might even give them behavioral *advantages* in specific skills or in specific environments. We have found, for example, that retarded children often learn simple discriminations faster than normal children (Lindsley, 1958; Barrett and Lindsley, 1962). Some retarded children have also shown considerable artistic talent. These superior skills in behaviorally handicapped persons are illustrated and interpreted in detail elsewhere (Lindsley, 1964c). The popular notion that superior skills in both behaviorally and physiologically handicapped persons are due to motivational compensation (they work harder since they have farther to go) is challenged. Four simpler interpretations of deficiency-produced superiority are offered: (1) less response competition; (2) easier career choice; (3) lowered thresholds; and (4) less behavior to extinguish.

I stress the possibility of behavior deficits resulting in specific advantages in

certain prosthetic environments to show that the prosthetic goal can be higherthan-average ability. We can make specific superior productivity the goal. Society may not only manage its retarded individuals with full efficiency and dignity, but in special cases reap profits not attainable from more generally skilled persons.

## Three Prosthetic Strategies

Three basic strategies have been successfully used in prosthetizing and rehabilitating the behaviorally handicapped: (1) construction of prosthetic devices; (2) prosthetic training; and (3) construction of prosthetic environments.

Prosthetic devices are worn or carried about by the handicapped person. They permit him to behave normally in an average environment. Some of these devices amplify the intensity or pattern of stimuli. Eyeglasses and hearing aids are well known. Other devices, such as braces, crutches, artificial limbs, wheel-chairs, and dentures, serve to strengthen or replace an individual's movements or responses. Even cosmetics are prosthetic devices, as they serve to reduce the avoidance responses of others. Well-known prosthetic cosmetics include makeup, hair dyes, wigs, and girdles. Prosthetic devices also include instruments of wide application to relatively minor behavioral deficits—for example, notebooks, appointment books, watches, slide rules, and computers. In effect, almost all the tools of man are prosthetic devices. What we need are special tools for the use of those unfortunate people who have relatively uncommon behavioral deficits. Since their deficits are exceptional, tools have not been developed to facilitate and support their behavior.

Specialized prosthetic training can be given to persons with certain behavioral handicaps to permit them to behave efficiently in average environments. It may be possible to lower sensory thresholds by training. Sensory deficits are more commonly treated by prosthetic training in receptor substitution. The best known of these techniques are lipreading and piano-feeling for the totally deaf and canetapping for the blind. Physical rehabilitators spend most of their time on effector substitution. Individuals are trained to use non-debilitated muscles to perform tasks which were previously accomplished by the injured or destroyed muscles. Those of us who grew up in the days before the Salk vaccine can remember the unusual and ingenious ways in which polio victims learned to substitute non-diseased muscle systems for performing routine daily activities. For people with poor memories, training in the use of mnemonic devices and memory systems is well known.

Prosthetic environments are much more common than most of us realize. Stimulus substitution techniques which are in common use include Braille books and magazines for the blind, bells which ring for the blind when the "walk" light is on at traffic intersections, and standardized traffic light position and intensity for the color-blind. Common effector substitutes are ramps, elevators, and handrails for those with walking disabilities, and specially designed homes and automobiles for paraplegics. The physiologically handicapped are actually behaviorally handicapped with deficits limited to effector or receptor function. However, higher-order forms of behavioral handicaps exist. Examples are discrimination and differentiation deficits, contingency and reinforcer deficits, and reflex integration disorders. These higher-order

Although prosthetic devices and training have the advantage of permitting a behaviorally handicapped individual to function within an average environment, their design usually requires detailed knowledge of the variables controlling the deficits. Since at this stage we cannot precisely describe higher-order behavioral deficits, the most practical immediate strategy would be to design prosthetic environments in which the deficient behavior is not needed, rather than attempting to provide prosthetic devices and training.

#### Acquisition vs. Maintenance Prosthesis

There is a great tendency today to confuse the acquisition of behavior with its maintenance. In fact, quite a different set of conditions is required to teach or initiate a behavior than is required to maintain the same behavior. Prior to the discovery of intermittent reinforcement (Ferster and Skinner, 1957), psychologists believed that every response had to be reinforced in order to maintain responding. Ferster and Skinner showed that even though it was necessary to reinforce almost every response in order to "shape" or generate a particular response, the proportion of responses reinforced could be rapidly reduced until the ratio of response to payoff was so high that organisms expended more energy in responding than they received in calories of food reinforcement. This surprising contradiction of behavioral homeostasis clearly demonstrates that the conditions necessary for acquiring behavior are different from those necessary for maintaining the same behavior.

Special educators, vocational rehabilitators, social workers, attendants, psychologists, and psychiatrists often maintain behavior with procedures which were only necessary for its acquisition. This happens because clinicians are strongly reinforced for helping debilitated individuals. It is reinforcing to them to be needed by a handicapped person and possibly aversive for some to be shown that they are no longer necessary.

The only way to insure that acquisition procedures are not inefficiently and unnecessarily used after the behavior is acquired is to remove them gradually. If the behavior breaks down, then the procedures should be put back until the behavior returns. As prosthetic techniques are removed, sensitive calibration of slight reductions in performance is necessary in order to prevent superstitious use of the techniques to maintain the behavior. Therefore, accurate and detailed direct measures of behavioral deficits must be routinely made to insure that maximally efficient prosthesis is maintained.

The difference between acquisition prosthesis and maintenance prosthesis cannot be overemphasized. It is almost as unkind to needlessly "crutch-trap" a handicapped person as it is to deny him a crutch in the first place. It is equally indecent to make a perpetual behavioral cripple out of an individual who only required a slight push over an acquisition "hump"—most especially when another patient goes without needed attention. <sup>6</sup> We must convince

1964b). The results suggest that schizophrenia is a disorder of reflex integration rather than reflex composition.

<sup>&</sup>lt;sup>5</sup> For several years, we have been recording interactions between simultaneously emitted operant reflexes in chronic schizophrenic and normal individuals (Lindsley,

<sup>&</sup>lt;sup>6</sup> I recognize the communication difficulty in writing across so many disciplines. What should we call the people we are trying to help: students, pupils, subjects, clients, or patients? Is the distinction between reward and reinforcement useful in the classroom? We often work with identical behavioral deficits, yet even our basic terms are dissimilar. Until we can rise above our protective technical jargons, we cannot profit from each other's skills. We must help each other in separating our

those engaging in behavioral prosthesis that acquisition prosthesis is more valuable and skillful than maintenance prosthesis. Only in this way will educators, rehabilitators, and clinicians be more reinforced for vanishing themselves and their techniques as soon as possible. Then the educator may move freely to a new patient who needs him more for acquisition prosthesis than his old patient needs him for maintenance.

## Free-Operant Conditioning

In free-operant conditioning the frequency of a chosen performance is altered by arranging suitable consequences (reinforcement). This procedure contrasts with Pavlovian conditioning in which behavior is manipulated by altering its antecedents. Free-operant conditioning has the advantage of dealing with emitted or "volitional" behavior which appears to have no antecedents and is of wide social concern. Since the individual being conditioned is at all times free to emit any response, the method interacts minimally with the behavior being studied. Environmental isolation of the individual within an appropriate enclosure permits the behavioral scientist to control experimentally rather than statistically—all environmental events which might affect the behavior he is studying. This high environmental control and automatic, direct, continuous recording qualify the method for inclusion in laboratory natural science. The history of free-operant conditioning (Skinner, 1959), its techniques (Ferster and Skinner, 1957), tactics (Sidman, 1960), wide social potential (Skinner, 1956), and successful applications in human psychopathology (Lindsley, 1960) and human social behavior (Cohen, 1962; Lindsley, 1963a) can only be referenced here.

Free-operant methods are especially suited to prosthetics for the behaviorally retarded for several reasons. Focus on *motivational aspects* or consequences in the immediate environment permits direct application of laboratory results to classroom and ward situations. Direct recording of the *temporal distribution* of behavior provides records of the attention fluctuations and seizures which are so common in retarded behavior. The sensitivity of the method to subtle changes in individual rate, efficiency, and interaction patterns permits the study of *single individuals*. Since these methodological advantages do not decrease with very long periods of application on the same individual, reliable *longitudinal studies* are possible. The highly significant experimental case histories generated by the method are ideal for comparison with individual clinical and social histories. The recently developed techniques of conjugate reinforcement and closed-circuit-televised social stimuli permit direct measurement of dynamic interpersonal relationships of high clinical relevance (Nathan, Schneller, and Lindsley, 1964).

Free-operant principles, methods, and terms may provide special educators with (1) a fresh theoretical approach; (2) laboratory description, prognosis, and evaluation; (3) individualized prosthetic prescriptions; and (4) designs for prosthetic environments.

# A Fresh Theoretical Approach

Free-operant conditioning principles and terms can provide a practical tool for helping special educators and vocational rehabilitors to increase the effi-

superstitions from our contributions. Only when we have dropped our disciplinary passwords by the wayside will our students maximally benefit from our mutual effort.

ciency of their education, training, and management of retarded behavior. In this new approach the educator or rehabilitator does not assume the role of playmate, custodian, policeman, or even sophisticated clinician. Instead, his role is that of a specialist in retarded behavior. He arranges the classroom, home, or institutional environment so that the children can play with each other and maintain their own personal dignity and deportment. The retarded-behavior specialist may turn over some problems to clinical experts trained to deal with them. The clinical experts can in turn do their job better since the retardation specialist can give a precise behavioral description of the

problem.

The current training, motivation, and philosophy of special educators and vocational rehabilitators are ideal for operant prosthetic methods. Their concern is with the children and their behavior. Their interests are practical, and their needs immediate and direct.

Most important in the practical application of free-operant principles are: (1) precise behavioral description; (2) functional definition of stimulus, response, and consequence; and (3) attention to behavioral processes.

Precise behavioral description facilitates communication between the teacher or rehabilitation counselor who is in direct contact with the retarded behavior and consulting behavioral and clinical specialists. Behavioral description not only focuses attention on the actual behavioral movement which is emitted at either too high or too low a rate, but also permits counting the frequency of the response and directly reinforcing it with suitable consequences. Accurate records of the frequency of response emission under different environmental conditions are absolutely necessary prior to developing efficient applied behavioral prosthetics. The prosthesis can be no more accurate than the descriptions of the target deficit and behavioral goal.

Functional definition of stimulus, response, and reinforcement focuses the attention of the special educator on the relationship between the behavior he is attempting to produce and his educational procedures. When the teacher realizes that what is rewarding to one child may be punishing to another and that a child may be so starved for human attention that a scolding serves as a reward, he has accepted the full complexity of human behavior and will no longer make gross errors in behavioral management based upon misguided empathy.

Attention to behavioral processes is extremely important for intelligent behavioral management. The processes of positive reinforcement, negative reinforcement, extinction, satiation, fatigue, response competition, and response differentiation are important alternatives which should be tried before the educator gives up on teaching a specific performance. There are numerous citations of successful use of these processes in eliminating extremely bizarre behavior. A good example is an application by Ayllon (1963a). He trained nurses to satiate a towel hoarder by filling her room with towels. When the number of towels in her room reached 625, the psychotic patient discarded them with vigor! She continued to discard towels until the number in her room averaged 1.5 compared to the previous 20 towels she hoarded. This example is given to stress the importance of trying all the available behavioral processes before one gives up on managing a behavior disorder. There may be many ways to manage a specific behavior.

Important for generating and maintaining maximal behavior in a classroom or ward is the establishment of a conditioned general reinforcer, or token. This token must be used to purchase all things of importance to the students.

Opportunities for play, recess, speaking to the teacher and to each other, sitting in "choice" seats, wearing a scarf of brilliant color, being first in line, and so forth, are highly reinforcing events which are usually so delayed that they are wasted. Recent research has proven that reinforcement must be practically immediate in order to be effective. In fact, some teachers even inadvertently use these powerful social reinforcers to reinforce inappropriate behavior, for example, by letting the bully always be first in line. If classroom tokens must be used to purchase the opportunity to perform desired behaviors, the teacher can then immediately deliver the tokens for educational and social progress. Ayllon (1936b) has taught psychiatric aides to use ward tokens in this way in training chronic psychotic patients to care for themselves and their ward.

#### Operant Behavioral Equation

In training special educators, vocational rehabilitators, and attendants to approach behavioral deficits operantly, I have found it useful to stress the four-component operant behavioral equation. The components of a single operant reflex (or behavior unit) are, in order: (1) stimulus; (2) response; (3) reinforcing contingency; and (4) consequence or reinforcement.

In diagramming the analysis of behavior, we use capital letters as the symbols for each component and separate them by dashes:

If the emission rate of the response is increased by the consequence contingent upon it, then the consequence is reinforcing and we mark it with a superscript "R." If the emission rate is decreased by the consequence, it is an attenuating consequence, notated by a superscript "A."

In analyzing a deficient operant to determine which component may be causing the deficiency, each component must be independently tested for operant function on each individual. We have given another set of names to events whose operant function is still unproven, to clearly separate them from components with proven, non-deficient function. These terms are: (1) antecedent event; (2) movement; (3) arrangement; and (4) consequential event. They are diagrammed as follows, with the superscripts "A" and "C" noting the events presented as antecedents and those which were consequential:

$$E^{A}$$
 —  $M$  —  $A$  —  $E^{C}$  event movement arrangement event (antecedent) (consequential)

An example will show how this notation system helps determine which component of a deficient operant is not functioning. A psychologist has tested a child's discrimination behavior. If the child operated a plunger on the wall when a light was on, every tenth pull produced a piece of candy. The child pulled the plunger and got some candy, but he pulled when the light was off as much as when it was on. What can the psychologist say, except that the child could not learn to pull only when the light was on? The psychologist

can say nothing more than this without further experimental knowledge of the behavior of that particular child. The operant equation now reads:

$$E_1^A$$
 —  $M_1$  —  $A_1$  —  $E_2^C$  light plunger pull FR-10 candy

Any one or more of the four operant components could be deficient. An operant equation with four unknown components cannot be solved for one unknown.

A prosthetically oriented psychologist would not assume that the child has a visual discrimination deficit. Nor would he try other consequential events. Nor would he manipulate the contingency arrangement. Instead, he alters the response component, because he had noticed when he looked into the room that the child's plunger pulling seemed "rhythmic" or "mechanical." The psychologist substitutes jumping-on-a-pedal for pulling-the-plunger as the movement component:

$$E_1^A$$
 -  $M_2$  -  $A_1$  -  $E_2^C$  light jumping FR-10 candy

The child only jumps for candy when the light is on! The psychologist has now discovered four operant components and can assign operant functions to the components in his equation:

$$S_1$$
 —  $R_2$  —  $\kappa_1$  —  $C_2^R$  light jumping FR-10 candy

The child has visual discrimination ability, has jumping as an operant response, has fixed-ratio 10 as an operant reinforcing contingency, and is reinforced by candy. The child has a response function deficit, probably involving the hands, but does not have restricted manual movement.

The psychologist can now use three of the demonstrated operant components to find out if the child will work for tokens:

$$S_1$$
 —  $R_2$  —  $K_1$  —  $E_3^c$  light jumping FR-10 token

This operant equation, containing three components with known function, can be solved for the unknown consequence (token) being tested. In other words, in order to pin down an operant deficit to one of its components, we must have only one unknown in the behavior equation we are trying to solve.

# Operant Component Building

In some cases of extreme behavioral deficit we cannot locate appropriate operant components with which to generate a required operant reflex. Sometimes these cases can be prosthetized by prosthetic training—by building the missing components.

Stimulus building techniques give to neutral environmental events the ability to elicit responses, i.e., stimulus function. If a different event which is a strong stimulus can be located, then the neutral event can be presented with the stimulus until it comes to elicit its own response by the classical conditioning process.

The possibility of using aversive stimuli to give neutral events stimulating function should not be overlooked. Circus trainers and early educators used this technique for extremely difficult stimulus building and found that only a few paired presentations were necessary. Since modern educational and conditioning techniques are so efficient with individuals of average and general ability, the use of aversive stimuli to classically condition stimulus function has been forgotten. It may prove to be irreplaceable in prosthetizing restricted but severe behavioral deficits in stimulus function.

Stimulus building should not be confused with stimulus shaping, or fading, which is well known to those working in programmed instruction. In stimulus shaping, some dimension of a neutral event is altered to the point at which it can serve as a discriminative stimulus for an existing intact operant reflex. Not only must all components of an operant reflex—response, contingency, and consequence—be available, but the individual must also be capable of discrimination. Responding only in the presence of the stimulus is reinforced. Then the dimension that was altered is gradually returned to the point that was previously non-stimulating, while the consequence is still contingent on responding only in the presence of the stimulus. The result of fading the stimulus is a sharpened discrimination, with previously neutral points on the dimension now functioning as stimuli.

Thus, in stimulus shaping, an event which cannot serve as a discriminative stimulus is given discriminative function by gradual modification of a stimulus dimension of an existing operant reflex. In stimulus building, an event which does not stimulate is made to do so without requiring an intact operant reflex.

Response building includes procedures whereby movements which cannot serve as responses in an operant reflex are given response function by special training. Although these procedures often puzzle academically trained psychologists, they are commonplace to empirically trained rehabilitators. Even a normal individual finds it hard to bring small discrete bands of muscle under operant control. However, if he practices in front of a mirror, he can use the visual feedback to build the response; and after a certain amount of such training, he no longer needs the mirror. External manipulation of limbs by physical rehabilitators, until the patient can eventually move the limb by himself, is an example of response building. The flight instructor's manipulation of the student pilot's hands and feet by the training joy stick and rudder pedals which are linked to his own is another example.

Consider the often puzzling case of negative practice (Dunlap, 1932). A movement emitted at a moderately high rate fails to decelerate when all reinforcing consequences are removed. We wish to decrease its emission rate. By reinforcing the movement which we wish eventually to eliminate, we increase its rate and build it into an operant response. Now, after we have built the movement into an operant response, we can extinguish it. We remove the reinforcing consequence, and the rate drops to a value far below undifferentiated movement emission rate.

Response building is not the same as response shaping, which is well known to experimental psychologists. In response shaping, an individual with an intact operant reflex is taught to produce a related, but more complex response.

The consequential contingency is gradually shifted to neighboring responses of slightly more complex topography, while the reinforcing consequences are delivered often enough to keep the individual responding. In this way, extremely complex response patterns can be shaped without verbal instruction.

Thus, in response shaping, a movement which is not emitted is produced by gradual modification of the response topography of an existing operant reflex. In response building, a movement which is regularly emitted but cannot serve as part of an operant reflex is given operant response function.

Contingency building is well known by operant conditioners. The number of responses to each reinforcement is gradually increased until the individual is responding on a contingency with a high degree of intermittency which would not have supported his behavior initially (Ferster and Skinner, 1957).

Consequence building is also well known by psychologists. Neutral events can be made into reinforcing consequences by pairing them with highly reinforcing consequences. Also, neutral events can sometimes be made into reinforcing consequences by depriving the individual of them for long periods of time.

Stimulus building and response building are seldom considered by psychologists but are often the stock-in-trade of educators and rehabilitators. Contingency building and consequence building are little known among rehabilitators but are subjects of refined laboratory study by psychologists. By putting together the information and techniques of special educators, rehabilitators, and psychologists with a uniform and precise notation system, we can cover the whole range of operant component building.

## Laboratory Description, Prognosis, and Evaluation

Free-operant conditioning methods can be used to develop behavior research laboratories for directly measuring human behavioral deficits. The first such laboratory was established by us at Metropolitan State Hospital in 1953. The most recent was established by Dr. Beatrice Barrett at Walter E. Fernald State School in 1963. Altogether there are over ten laboratories in daily operation; four of these specialize in recording deficits in retarded behavior (Orlando and Bijou, 1960; Ellis, Barnett, and Pryer, 1960; Spradlin, 1962; and Barrett, 1963). Over 30 of these laboratories operate intermittently, due to the irregularity of thesis research and graduate assistance.

In brief, these laboratories consist of several small experimental rooms which provide controlled environments in which behavior deficits are automatically recorded. Subjects are brought to a room by an aide and permitted to behave freely for a period of time long enough to measure the presence and degree of certain behavioral deficits. The experimental rooms differ from each other only in the equipment necessary to manage different types of persons and to record different behavioral deficits. Three rooms equipped to record very different behavioral deficits in our own laboratory are described below as examples of the makeup of these laboratories.

We have designed an experimental enclosure and apparatus for generating operant responding in human infants as young as five months of age (Lindsley, 1963a). The infant lies in a small bassinet with his feet against a large panel which can be depressed about one-half inch. Each depression of the panel briefly increases the intensity of a lamp in a movie projector, permitting the infant to see the movie. Rapid pressing of the panel makes the

projected image grow brighter and brighter, directly relating the rate of panel-pushing to the intensity of the movie. These contingencies externalize the looking behavior of the infant and make the panel-pushing response a looking response. In this way continuously changing narrations can be used to maintain the behavior of extremely young infants at high, even rates. In previous research using brief episodes of music, sound, colored lights, and projected slides as reinforcement, infants behaved in irregular bursts of 5 to 30 responses. We feel that it is the use of conjugate reinforcement, together with a large response panel which does not require discrete movements for operation, which permits generating steady, rapid responding in such young infants.

This apparatus can be used to measure the infant's interest in different filmed, televised, or closed-circuit-televised narrative social rein forcers (such as his mother's smile as compared with his father's). It can also be used to generate behavior for laboratory testing of discrimination, differentiation, and learning ability to different classes of stimuli. Signs of retarded behavior may be picked up in the first few months of life with such equipment. Then, individualized prosthetic techniques could be prescribed and perhaps the development of marked retardation arrested.

By designing stimuli (vibrations or sounds) which can enter the uterus and by using delicate electrical movement transducers which can record movements of the fetus within the uterus, we might be able to operantly condition fetus behavior. We could then directly measure the rate of development of fetal behavior. It is even possible that we could determine individual differences in discrimination ability and thus predict retardation prior to birth. All that this requires is slight modification of devices and techniques which are already available and proven.

In another room, we can directly and continuously record the interaction between plunger-pulling reinforced with small objects (candy, coins, toys, or tokens) and symptomatic hypermotilic pacing in children and adults. With this device, we found that the majority of chronic psychotic patients are most able to manipulate the immediate environment for reinforcement at the times when they are also pacing—a result that surprised us very much. This apparatus, with an additional channel which records the rate of vocalizing through a hidden microphone, is currently used to evaluate simultaneously the effects of psychotherapeutic drugs on symptomatic pacing and vocalizing and adjustive manual responding of psychotic and retarded individuals. By continuously recording an individual's output of these three behaviors throughout a seven-hour experimental session, we can directly analyze interaction among them. Patients willingly work for seven hours within our experimental rooms if the reinforcement is adequate.

Recent results suggest that children show fatigue during the last three hours of these seven-hour sessions whereas adults do not. Retarded children, when fatigued, begin to emit all three behaviors at once, spending brief periods of time doing nothing. This pattern is also found in a large number of psychotic patients—but throughout the session. Normal children, on the other hand, show something more like boredom; in the last three hours, their manual responding is not interrupted, but they pace for brief periods (Lindsley, 1964b). Direct recording of simultaneously emitted reflexes promises to shed light on higher-order behavioral processes which have previously been beyond the scope of direct laboratory measurement. The interaction between and the integration of separate reflexes should tell us much

In a third experimental room, we simultaneously record discrimination, differentiation, and excessive inefficient generalization in both children and adults. The subject sits comfortably in front of a wall-mounted panel, on which are two lights with a plunger under each. A small object (candy, coin, token, or toy) drops into a receiving bin in the panel for every tenth pull of the left plunger only when the left light is on. If the subject learns to pull the left plunger only, regardless of which light is on, he has learned to differentiate or tell the plungers apart. If he learns to pull both plungers when the left light is on and pulls neither when the right light is on, he has discriminated or told the lights apart; but he has not differentiated since he is pulling both plungers. If he learns to pull only the left plunger when the left light is on and only the right plunger when the right light is on, he has both discriminated and differentiated but has excessive inefficient generalization (pulling the one under the light). This generalization is inefficient and maladjustive because pulling the right lever with the right light on has never been reinforced. Such excessive generalization is so strong that in certain psychotics it resists both counterreinforcement and direct punishment with mild or even strong shocks presented to the right lever.

So far we have screened the discriminative and differentiative behavior of over 140 individuals using this procedure. None of the normal adults showed deficits. Sixty percent of the normal and forty percent of the retarded children, 11 to 14 years of age, showed no deficits. Only about ten percent of the psychotic adults, seniles, and psychotic children showed no deficits. These results strongly suggest that the current novel learning ability of the retarded child in a controlled environment, although below that of the normal child, is markedly superior to the current learning ability of psychotic adults and children. These laboratory data support our notion that environmental prosthesis may be more effective with retarded than with psychotic individuals.

The severe deficits in current learning ability in adult and senile psychotic patients were initially surprising, since many of these patients had large repertoires of complex individual and social behavior which they could emit in appropriate situations. The laboratory measurements proved, however, that their current discrimination abilities in a novel situation were extremely deficient. In retrospect our findings made sense, because the chronic psychotic adults in most cases had about 20 normal years during which they acquired large and complex repertoires. The senile psychotics had an even longer time, in most cases around 60 years, in which to acquire complicated behavioral repertoires. In other words, the severe learning deficits which are a property of their psychoses did not develop until after they had acquired a wide range of complicated appropriate behavior. Clearly, appropriate emission of a complicated response is no indication that a response of equal complexity can be currently acquired. Children who have had retarded behavior and learning deficits since birth and have been in only average environments have had no opportunity to acquire complicated repertoires.

Current learning ability cannot be accurately assessed by sampling current behavioral repertoires in classrooms or wards. The current learning ability of geriatric and psychotic patients may be exaggerated by the influence of the behavioral repertoires they acquired prior to their deficiencies. The current learning ability of retarded individuals may be underestimated by casual observation since they have never had opportunity to develop complicated

behavioral repertoires. Faulty assessment of current learning ability in terms of current repertoire, added to the fallacy of *similia similibus curantur*, has erroneously placed retarded behavior at the bottom of the list of prospects for environmental treatment and re-education.

Fully automatic programming of stimuli and recording of responses in behavior laboratories insure completely objective measurement. Since technicians do not intervene between the patients and the automatically recorded data, they do not introduce complicating observer bias. Longitudinal studies are not disrupted or complicated when technicians are changed. Cross-hospital and cross-cultural comparisons are possible since language is not necessarily involved in the behavioral measurement. The opportunity to dispense with verbal instructions permits analysis of non-verbal patients.

Laboratory measures of the behavioral deficits of each individual patient should be included in the patient's case history and should be regularly used to evaluate the effects of therapeutic variables. The effects of medication and of such social variables as teacher and ward reassignment, home visits, and hospital events can be easily determined. In this way, detrimental treatments can be rapidly terminated before much damage is done to the patient. Individualized behavioral treatment can then be conducted with the same precision with which individualized physiological treatment is now conducted in well-staffed general hospitals.

## Design of Prosthetic Environments

Since retarded behavior is undoubtedly the result of morbid interactions between a large number of organic and environmental causes, there is little hope of totally preventing its occurrence in the near future. However, we can reduce its debilitation by designing environments which compensate for the specific behavioral deficits of each retarded person. Since these environments will not remove the behavioral deficits, but will merely eliminate the debility caused by the deficits, they cannot be considered completely therapeutic. Therapeutic environments would generate behavior which would be later maintained when the individual was returned to a normal or average social environment. Prosthetic environments must operate continually in order to decrease the debilitation resulting from the behavioral deficit.

Weiner (1963) also has stressed this basic difference between irreversible therapeutic variables and reversible prosthetic variables and the problems this difference poses for therapeutic research design. Although I am also concerned with research design problems, I suggest that prosthetic variables have great utility in managing behavior for which we have not yet located a permanent therapy. In this section, I make suggestions for designing prosthetic environments for retarded behavior. In order to make these suggestions as accurately as possible I will use the components of the operant behavioral equation described above as a classification system. The number of different types of prosthetic stimuli and programs required for prosthesis of the behavior of a given individual cannot be determined until the number, degree, and range of behavioral component deficits of that individual are accurately determined. In many cases a given prosthetic device can be used to prosthetize more than one type of behavioral deficit, and often a single behavioral deficit

<sup>7</sup> Barrett (1963) has recently stressed the need for individualized prosthetic prescriptions based upon laboratory behavioral measurement for use in designing individually tailored programs of instruction for children with retarded behavior.

can be prosthetized by more than one device. In these cases, the most economical and most general devices should be selected first.

Although I cannot review the literature here, several research groups have recently shown that prosthetic or responsive environments can produce dramatically efficient behavior in culturally deprived children. Two excellent recent studies are those of Moore (1963) and Blatt, Garfunkel, Sarason, and Brabner (1964).

These suggestions for designing specific prosthetic environments for retarded individuals are certainly not exhaustive. They are only examples for the direction of future research and practice. The range and quality of prosthetic devices are limited only by the creativity of behavioral scientists, whose time, funds, and novelty of approach are in turn limited only by society's interest in providing behavioral dignity for retarded persons.

#### Prosthetic Stimuli

Environmental events which signal when a response is appropriate (i.e., it will be reinforced) and when it should not be made (i.e., it will be extinguished or punished) are extremely important in controlling behavior. Traffic lights are a familiar example. Although many people do not realize it, different clothing styles commonly function as discriminative stimuli. The stimulus function of differently colored and designed uniforms is a matter of life and death to soldiers at war. The uniform of the policeman is designed to elicit specific responses from the general public. Sex differentiation in clothing is also important, despite its increasing subtlety. Many responses appropriate to a person wearing a dress are not appropriate to a trousered individual. The retarded individual may have behavioral deficits which limit the range of discriminative stimuli in the average environment which can control his behavior. Stimuli to which the retarded individual can differentially behave can be added to the average environment so that his behavioral deficits will no longer limit his action.

The *intensity, size, and number of discriminative stimuli* for retarded behavior have received some prosthetic attention. Special educators working with retarded children often use simple and dramatic patterns, long durations, and higher intensities of stimulation than are used in educating normal children.

Multiple sense displays are not as frequently considered for stimulus prosthesis. A retarded individual might not respond appropriately to a loud sound alone or to a bright light alone, but he might respond appropriately to simultaneously presented sound and light. The more primitive tactual, vibrational, and olfactory stimuli should be considered for multiple sense displays. In a case of extremely severe retardation, it may be that no conditioned stimuli can be used, while unconditioned primitive eliciting stimuli could be used. For example, individuals who could not learn to follow a previous path or printed signs to the toilet might very well follow an odor trail by themselves. A regressed retarded individual might learn more easily to use a malodorous toilet than a floral-scented toilet designed for normals. This unpleasant procedure would be far less unpleasant than its alternative— untidy bedding, classrooms, and clothing.

Expanded narrations should be tried with children who have deficits in responding to narrations which unfold at normal rates. Melrose (1962) has found that many aged persons who cannot hear normal speech can hear expanded speech. Expanded speech is merely spread out more in time and

does not differ in intensity or tone from normal speech. Just as some aged persons cannot respond to information presented at the normal rate, some retarded persons might show the same deficiency. Tape recording systems could be used to expand visual materials in addition to auditory materials. By slowing down both auditory and visual channels of educational films and broadcasts we might be able to prosthetize narrative stimulus deficits. It is also possible that expanded auditory and visual narrations would have a reinforcing value for some retarded individuals when the same narrations presented at the normal rate would not.

Response-controlled discriminative stimulation should be tried as a prosthetic technique for retardates who appear to have intermittent attention or behavioral seizures. When an individual is periodically unresponsive to stimulation, the stimuli which occur during these unresponsive periods are lost to him forever. Appropriate responding is impossible because for him the world has missing portions.

In response-controlled narration, the narration moves along only when the patient is actively responding to it. When the patient goes into an unresponsive period or behavioral seizure, the narration is stored until the patient responds again. The stimulus can be stored either by stopping the tape or film or by running a small continuous loop which repeats the last narrative event responded to. Even dynamic direct social presentations can be response controlled. For example, a teacher who had a direct moment-to-moment index of the retarded student's attention could halt his delivery when he noticed the child was in an unresponsive episode. When the attention of the child returned and the looking and listening responses reappeared, the teacher could begin his presentation where he left off. With this technique, "dead" portions in the patient's attention would merely increase the total presentation time without removing essential portions of the narration.

Catalysis of seizures in groups of seizure-prone individuals could be conducted so that all of a special class could have their seizures in a safe place at a time when the seizures would not interfere with educational presentations. This possibility is not remote. It merely awaits the discovery of useful catalytic stimuli. Most researchers, continually searching for alleviating or therapeutic events, overlook the opportunity to discover catalytic events which induce behavioral disorders. However, Cameron (1941) placed senile patients in dark rooms and was able to catalyze or induce senile nocturnal delirium. This proved that senile nocturnal delirium was not due to end-of-the-day fatigue as had been previously supposed. Rather, the delirium was due to the darkness and reduction in stimulation which also came at the end of the day.

In our laboratory we catalyzed vocal hallucinatory episodes in some chronic schizophrenics by calling their names over speakers hidden in the experimental room. Our data suggest that catalysis of hallucinatory episodes reduces their spontaneous frequency of occurrence not only within the experimental room, but also during the rest of the day when the patients return to the wards (Lindsley, 1963b). In earlier experiments we discovered that in some patients psychotic episodes could be catalyzed by fixed-ratio reinforcement schedules. Their bizarre behavior appeared only during the pauses after reinforcement. During the time the patients were pulling plungers for candy and cigarette reinforcements, the psychotic episodes did not occur. We also have evidence that the psychotic episodes of a few patients are catalyzed when the patients are given problems they cannot solve.

These suggestions for catalyzing seizures and episodes of disturbed behavior

at times when the patients can be well cared for and when the episodes would not interfere with educational presentations are presented as examples of the sort of prosthetic techniques which can be undertaken once we fully understand specific behavioral disturbances. We may not be able to eliminate the disturbances totally, but we could make great progress by bringing the disturbances under environmental control and producing them when they can do no harm to the patient or his education. For example, the exercise or recess period, which many consider essential for proper management of children's behavior, may actually be serving as a prosthetic group disturbance catalyzer. The excessive exuberance and motor behavior which would intermittently disrupt classrooms are catalyzed in all students at once in the school yard where they harm neither the students nor their education.

## Prosthetic Response Devices

The response component of retarded operant behavior is a major problem and debilitates a large number of children. Recent research has shown that response differentiation deficits are severe in some children and greatly resist strong differential reinforcement (Barrett and Lindsley, 1962). However, in intelligently designed prosthetic environments which do not require fine response differentiations, this deficit could be easily bypassed.

Wide response topographies would eliminate the handicap of inaccurate finger placement and palsied movements. For example, telephones with push buttons or a voice-operated system would completely prosthetize dialing deficits. Electric typewriters with large, well-spaced keys which could be banged with the fist would prosthetize typing and writing deficits in children with extremely palsied movements. Arm-operated water faucets, of the type used on surgeons' washbasins, and doorknobs and window locks of similar design would permit children with motor deficits to manipulate their prosthetic environments efficiently. It is amazing that we have not provided such handicapped persons with more easily manipulated clothing fasteners, when some normal children with extremely skillful motor coordination take years to learn to tie their shoes, button small buttons, and operate zippers. Think of the indignity imposed upon an individual who simply cannot control his hands accurately and must have someone else button his trousers.

Rate switches which must be repeatedly pressed at a high rate could be used to prosthetize individuals with intermittent or weak attention. Even with normal individuals, foot switches which must be continually depressed by the operator have greatly reduced industrial accidents. When the operator turns away from the machine, his foot comes off the control switch and the machine automatically stops. In the same way, a higher degree of constant attention is demanded by rate switches. A switch that must be continually pressed should reduce the accident hazards to individuals with attention disorders operating dangerous machinery. If their attention drifted or a petit mal seizure occurred, they would fail to press the switch at the required rate, and the machine would automatically stop.

Response feedback systems could be used to correct response location errors before they actually occurred. For example, a capacitive sensing device at the side of a needle on a sewing machine could sound a tone louder and louder the closer the fingers came to the stitching needle. Such feedback stimuli should greatly compensate for deficient kinesthetic ability and afferent input and not only prevent accidents but increase manual skill.

Response building techniques, which were previously discussed, should of

course be tried. To some extent, response feedback systems may serve as prosthetic training devices for building responses from movements which previously could not serve as operant responses. We could merely reduce the intensity of a feedback tone to see if it were still required for maintaining the behavior. If it were not necessary, the feedback stimulus could be eliminated for that now therapeutized response deficit.

#### Prosthetic Contingencies

In social situations, when the reinforcing consequences are episodes or discrete events, the reinforcement almost always occurs intermittently (Ferster, 1958). That is, only some responses are immediately followed by a reinforcing episode. Despite this, normal individuals continue to respond at high, even rates. This responding is presumably maintained by conditioned reinforcement from the occasionally reinforced responses. However, our experiments with retarded and psychotic children and adults have shown that many are unable to maintain high rates of responding on intermittent schedules of reinforcement, even when adequate reinforcers are used (Lindsley, 1960). These deficits in intermittent reinforcement contingencies are probably related to deficits in recent memory and in formation of conditioned reinforcement.

A large portion of patients with deficits on intermittent reinforcement contingencies respond at normally high rates when we use a conjugate reinforcement contingency, in which the intensity of a continuously available reinforcer is a direct function of the response rate. A conjugate contingency is analogous to the chase, whereas an episodic contingency is analogous to the hunt. On the conjugate program, some aspects of the reinforcing stimulus are present (though rapidly waning) during brief pauses in responding, as in the chase when a dog follows an odor trail. On episodic contingencies, all aspects of the reinforcing stimulus are absent during pauses in responding; and if the ratio of responses to reinforcement is high, many of the responses are emitted in the absence of the reinforcing stimulus. As in the hunt, some higher-order behavioral process must be used to maintain the behavior at high strength. It seems clear to me that conjugate reinforcement, like the chase, requires only primitive or basic behavioral processes, and hence it is not surprising that it goes deeper into sleep, anesthesia, infancy, and psychosis than does episodic reinforcement (Lindsley, 1961). For these reasons conjugate reinforcement contingencies should be tried as prosthetic techniques for retarded behavior that shows deficits on intermittent reinforcement contingencies.

## Prosthetic Consequences (Reinforcers)

Although most of the retarded behavior we have studied does not show marked deficits in interest or motivation attributable to inappropriate consequences, some discussion of this reflex component would be valuable for the occasional individual who shows such deficits. Most retarded individuals respond at high rates with great perseveration. Their responding in average environments is inefficient mostly because they show little stimulus discrimination and poor response differentiation (Barrett and Lindsley, 1962).

*Individualized social consequences* should be tried as reinforcers when normal social events do not maintain an adequate rate of responding. Casual observation of individuals with retarded behavior and a few laboratory experiments suggest that retarded individuals are either greatly deprived of social reinforcers or more reinforced by social than by non-social events. Conjugately

programmed social contact with another person via closed-circuit television can be used to study within the laboratory the prosthetic value of social reinforcers for retarded behavior. (See Nathan, Schneller, and Lindsley, 1964, for a description of methods.) In the classroom, social contact could be withheld and used to reinforce the acquisition and maintenance of skills.

Generalized conditioned reinforcers or tokens should be considered as prosthetic techniques. However, one must realize that although tokens are ideal for classroom use with the educable retarded population, they might have limited application with the severely retarded because of their deficits in formation of conditioned reinforcement.

Expanded narrations may serve as reinforcing consequences for retarded behavior that it not reinforced by the same narration presented at normal rates. The possibilities of expanded narration, suggested by Melrose's (1962) recent research, were discussed in more detail in the previous section on prosthetic stimuli.

Compressed narration, in which narratives are played at higher than normal rates, could be tried as a prosthetic device for retarded behavior that cannot be prosthetized by expanded narration. Although I have no experimental evidence, I suggest this possibility because of the high interest of normal and retarded youngsters in extremely rapid music and chipmunk-singing sound effects. This field observation suggests that some retarded behavior might be highly reinforced by highly compressed music and social narration.

Exaggerated social reinforcers might also be tried as prosthetic reinforcers for retarded behavior. Both normal and retarded children seem to show high interest in the exaggerated expressions on clown faces, in movie cartoons, and in movements of professional entertainers of children. Special educators might try exaggerating their smiles, approval, and caresses as prosthetic consequences.

It is true that the discovery and presentation of prosthetic devices have higher initial cost than the mass-produced average behavioral components which are now used in special education. However, the use of prosthetic devices should generate such high rates of appropriate behavior in retarded individuals that the increased cost would be more than compensated for by savings in education, social welfare, and institutional care.

#### Conclusions

Free-operant methods show a special promise for laboratory analysis and both acquisition and maintenance prosthesis of retarded behavior. There is mounting evidence that the more circumscribed behavioral deficits found in retarded individuals are easier to prosthetize by appropriately designed environments than are the psychotic deficits of wider scope. In fact, some of the deficits found in retarded behavior might even prove advantageous in certain environments.

A properly designed special school or class should treat individually and use maximally the behavior of its retarded students. Special educators should arrange suitable prosthetic programs for each student. The need for a given prosthetic program for each child should be continually tested to determine when the program can be efficiently reduced or replaced with a new program to generate a higher order of behavior.

Retardation is not the property of a child but of an inadequate child-environment relationship. It is our ability to design suitable environments for excep-

tional children that is retarded. Classrooms should be tailored to children—not children adjusted to classrooms. Retarded behavior is penalized and any subskills ignored in environments designed for average children. In prosthetic environments tailored to their skills, exceptional children will behave adjustively, efficiently, and with full human dignity.

#### References

Ayllon, T. Intensive treatment of psychotic behavior by stimulus satiation and food reinforcement. *Behaviour Research and Therapy*, 1963, 1, 53-62. (a)

Ayllon, T. Personal communication. 1963. (b)

Barrett, B. H. Reduction in rate of multiple tics by free operant conditioning methods. *Journal of Nervous and Mental Disease*, 1962, 136, 187-195.

Barrett, B. H. Programmed instruction and retarded behavior. Paper read at American Association on Mental Deficiency, Portland, Ore., May 1963.

Barrett, B. H., and Lindsley, O. R. Deficits in acquisition of operant discrimination and differentiation shown by institutionalized retarded children. American Journal of Mental Deficiency, 1962, 67, 424-436.

Blatt, B., Garfunkel, P., Sarason, S. B., and Brabner, G. Educating intelligence: A study in the prevention of mental retardation. 1964 (in preparation).

Cameron, D. E. Studies in senile nocturnal delirium. Psychiatric Quarterly, 1941, 15, 47-53.

Cohen, D. J. Justin and his peers: An experimental analysis of a child's social world. Child Development, 1962, 33, 697-717.

- Dunlap, K. *Habits: Their Making and Unmaking.* New York: Liveright, 1932. Ellis, N. R., Barnett, C. D., and Pryer, M. W. Operant behavior in mental defectives: Exploratory studies. Journal of the Experimental Analysis of Behavior, 1960, 3, 63-69.
- Ferster, C. B. Reinforcement and punishment in the control of human behavior by social agencies. Psychiatric Research Reports, 1958, 10, 101-118.
- Ferster, C. B., and Skinner, B. F. Schedules of Reinforcement. New York: Appleton-Century-Crofts, 1957.
- Lindsley, O. R. An analysis of operant discrimination and differentiation in chronic psychotics. Paper read at Eastern Psychological Association, Philadelphia, April 1958.
- Lindsley, O. R. Characteristics of the behavior of chronic psychotics as revealed by freeoperant conditioning methods. Diseases of the Nervous System, monograph supplement, 1960, 21, 66-78.
- Lindsley, O. R. Conjugate reinforcement schedules. Paper read at American Psychological Association, New York, September 1961.
- Lindsley, O. R. Operant conditioning methods in diagnosis. In J. H. Nodine & J. H. Moyer (Éds.) Psychosomatic Medicine: The First Hahnemann Symposium. Philadelphia: Lea & Febiger, 1962, pp. 41-54.
- Lindsley, O. R. Experimental analysis of social reinforcement: Terms and methods. *American Journal of Orthopsychiatry*, 1963, 33, 624-633. (a)
- Lindsley, O. R. Direct measurement and functional definition of vocal hallucinatory symptoms. Journal of Nervous and Mental Disease, 1963, 136, 293-297. (b)
- Lindsley, O. R. Geriatric behavioral prosthetics. In R. Kastenbaum (Ed.) New Thoughts on *Old Age.* New York: Springer, 1964 (in press), (a)
- Lindsley, O. R. A functional systemic analysis of schizophrenia. Paper read at American Psychopathological Association, New York, February 1964. (b)
- Lindsley, O. R. Idiot savant—Mystery or challenge? Submitted for publication, 1964. (c) Melrose, J. Research in the hearing of the aged. Paper read at National Association for Music Therapy, Cambridge, Mass., October 1962.
- Moore, O. K. Autotelic Responsive Environments and Exceptional Children. Hamden, Conn.: Responsive Environments Foundation, 1963.
- Nathan, P. E., Schneller, P., and Lindsley, O. R. Direct measurement of communication during psychiatric admission interviews. Behaviour Research and Therapy, 1964, 49-57.
- Orlando, R., and Bijou, S. W. Single and multiple schedules of reinforcement in developmentally retarded children. Journal of the Experimental Analysis of Behavior, 1960, 3, 339-348.

- Sidman, M. Tactics of Scientific Research. New York: Basic Books, 1960.
- Skinner, B. F. Science and Human Behavior, New York: Macmillan, 1956.
- Skinner, B. F. Cumulative Record. New York: Appleton-Century-Crofts, 1959.
- Spradlin, J. E. Effects of reinforcement schedules on extinction in severely mentally retarded children. American Journal of Mental Deficiency, 1962, 66, 634-640.
- Weiner, H. Laboratory studies of "non-adjustive" human operant behavior. Technical Report No. 15, Behavioral Studies Branch, Saint Elizabeths Hospital, Washington, D. C., December 1963.
- Zubin, J. Personal communication. 1963.