Behavioral Assessment of Lead Intoxication in Children*

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Current questions about lead exposure focus on the consequences of levels too low to have erupted into blatantly discernible defects. The present paper addresses two sets of interrelated problems derived from this issue. One is how to define the behavioral consequences of asymptomatic lead absorption, and the second focuses on behavioral assessment procedures.

Current primary prevention programs emphasize environmental monitoring, and early detection programs emphasize lead body burden measurements. The evaluation of behavioral problems in school children as a function of body burden is rarely performed. Epidemiologic data indicate sufficient natural variability to determine the degree of association between indices of total body burden and behavior. Assessment procedures are described and research suggestions offered that sample concretely defined target behaviors in social environments.

By now, it is hardly necessary to document the risk of lead intoxication for young children in older housing. In some communities, as many as 25% of the children reveal elevated blood lead levels. This is not to say, however, that one-quarter of the children will suffer acute lead intoxication with the accompanying syndrome of lethargy, irritability, colic, coma, seizures, and possible death. The incidence of these flagrant symptoms associated with such intoxication has fallen remarkably in recent years.

A more direct concern is how to evaluate the functional consequences of asymptomatic but elevated lead absorption, a concern emphasized in the recent National Academy of Sciences survey of lead (*1*). At this time, the behavioral correlates of elevated lead body burdens cannot be specified clearly. Although a child with blatant symptoms permits some reasonable inferences about the contribution of lead, the presence of elevated lead levels permits almost no inferences about behavior.

The problem, then, is how to determine the behavioral and psychological consequences, if any, of exposures to lead that produce tissue levels close enough to the

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range of clinical intoxication to arouse suspicion.

In their review of the consequences to childhood lead poisoning, Chisholm and Kaplan (*2*) indicate that the relationship between dysfunction in cognitive, behavioral, and social performance, and overt encephalopathy, is uncertain. Furthermore, these relationships are complicated by the observation that the symptom clusters do not necesarily remain stable. For example, as puberty approaches, some behavioral problems, such as aggressivity, may "mature out." Unfortunately, it is also possible that new problem behaviors emerge from unspecified developmental processes, as is sometimes seen in children diagnosed as suffering from minimal brain dysfunction (MBD), a syndrome, incidentally, compatible with an etiology of lead poisoning (*3*).

In a critical review of research on the question of consequences to children with elevated lead levels but without encephalopathy, Weiner (*4*) concluded that the literature was equivocal and that the inability to draw definitive conclusions arose primarily from methodological shortcomings. Much of the work failed to control, or report, critical variables in the patient's history such as age, socioeconomic status, and general health. Furthermore, even on occasions on which this information was available, it apparently was neglected. Naturally varying levels of lead ingestion and flaws in design and analysis have converged to make summary statements rather tentative. Yet, there is enough to make one suspect that children who live in environments that predispose them to elevated lead ingestions, even with no evidence of encephalopathy, may still display important behavioral consequences.

Let us summarize what the literature offers. First, beyond question, there is a long-lasting syndrome associated with acute lead intoxication; the sequelae persist. Second, elevated lead body burdens do not necessarily produce immediate and overt consequences. Parallels exist elsewhere that caution us about trying to identify the manifestations of poisoning at only one particular time. The behavioral consequences of early exposures to methylmercury may not emerge until later in the life span of the organism (*5*). Third, the sequelae of acute intoxication, i.e., disruptive and impulsive behavior and distractibility, resemble the target behaviors of minimal brain dysfunction, a diagnosis sometimes accused of being a "waste-basket" residual diagnostic category. Still, the hypothesis that MBD may in part be associated with early childhood lead poisoning (or some other pollutant) is not totally unreasonable. Finally, while some children may recover from poisoning, possibly as many as 75%, significant intellectual impairment may be a consequence for many. There are few children whose scores on tests of intellectual function lie in the superior range or beyond following an episode of acute lead intoxication. The ominous implications of such a legacy need to be explored in appropriately designed and well-executed full-scale studies.

Traditional Psychological Assessment

Traditional approaches, e.g., psychometric testing, characterize most efforts to assess the psychological consequences of lead exposure. Typically, these tests require a child to perform a series of tasks that embrace a broad spectrum of skills. Psychomotor coordination, attention, reasoning, general information, comprehension, and memory may all be sampled. Performance on these tasks will form the basis for estimates of intelligence. On occasion, a parent or other adult observer such as a teacher serves as an informant, and the interview product, or rating, provides an impression of the child's social functioning.

Many useful clues and even instruments are available from psychopharmacology. For example, a recent publication from the National Institute of Mental Health (*6*) surveys a variety of instruments employed to diagnose and measure behavior disorders and drug response in children. An exceedingly useful review of techniques for measuring sensory, motor, and intellectual processes has

been provided by Chalfant and Schefflin (*7*).

However, these assessment procedures, while valuable, must remain indirect and approximate measures of important behavioral dimensions. They do not provide the information necessary to determine the presence, absence, or extent of distractibility, impulsivity, or uninstigated aggression in a child's daily interactions, apparently key behaviors in lead poisoning.

A Behavioral Approach to Assessment

Traditional procedures are not to be totally disregarded but need to be supplemented with behavioral data based on techniques derived from applied behavioral analysis (*8–10*). Data produced by these procedures offer many advantages. First, hypothetical processes do not have to be puzzled over; only observable behaviors are recorded. Second, reliance on "impressions" or "guesses" that form the basis of parent and teacher rating forms, currently the data for much research on children, is minimized. Instead, one examines a particular target behavior in a specified natural setting.

A behavioral approach to assessment is not concerned with speculations about covert processes, such as "motivation," that abound in discussions of social behavior. Rather, it emphasizes the counting and recording of behaviors that are exhibited by the child. To say that a child is lazy, needs affection, or is impulsive does not provide public opportunities to verify behavior. If we wish to examine attentional problems, for example, then we must provide observable criteria which define "on-task" or "off-task" behavior. In the same way, to determine if a child is disruptive, one can count the number of behavioral intrusions in a classroom. Aggressive behavior can also be tallied in precise and objective ways.

Bijou et al. (*9*) have identified four requirements for the accurate description of behaviors in natural, as opposed to laboratory environments. First, a particular setting must be identified within which the observations will occur. This might be the home, classroom, or playground. Second, the behavior in question and its environmental antecedents and consequences should be susceptible to public description. It is critically important to develop observable criteria that define a target response and a coding system by which counting and recording may be carried out. The third requirement is reliable observations. All research hinges on the stability of our observations, and behavioral recording in natural settings is no exception. Consequently, the refinement of the observational code, the training of observers, and the procedures used to assess agreement among observers, must all be monitored carefully. If our observations are unstable, the likelihood is great that its cause originates in one of these sources. Finally, these authors stress the need to plot data regularly, to be careful in the transformation of data, and to offer interpretations consistent with the empirical observations and manipulations.

Some examples from this literature may be helpful. Walker and Buckley (*11*), working with a 9-year-old boy, defined nonattending behavior as straying from an assigned task. They provided the child with programmed materials and defined the behavior more concretely as follows: "(a) looking away from the text and answer sheet by eye movements or head turning; (b) bringing an object into the field of vision with head and eyes directed towards paper (other than pencil, book, and answer book necessary for the task); and (c) making marks other than those necessary for the task (e.g., doodling)." Elsewhere, a "talk-out," defined as any occasion on which "a pupil directed a verbalization toward the teacher without permission," was the basis for an intervention program in a first grade classroom (*12*). Similarly, a child who was "expelled" from two nursery school programs because of aggressive behavior, was studied in the home with the data collected by the mother by making physical aggression, yelling, and bossing susceptible to easy scoring. Physical aggression was defined as "hitting, pushing, kicking, throwing, biting,

scratching;" yelling in terms of loudness, and bossing as "telling other adults or children to do or not do something" (*13*). Each of these observations or sequences produced data that were easily recorded and that observers could agree on.

Again, such procedures require that a particular setting be specified within which the target behavior is evaluated, e.g., the home, the school, the playground; that observable terms be used in the description of the target behaviors; and, finally, that these terms become a code with which observers may time-sample behavior.

Time-sampling, basic to this approach to assessment, is a procedure in which a temporal unit is defined and the occurrence of particular target behavior scored. It can be used in different ways. For example, one might record all the occasions on which a response occurs during a particular time-frame. All instances of a child's crying from 8:00 P.M. to 8:00 A.M. might be recorded. This procedure may be contrasted with a more extended time frame during which sub-units are sampled. This is a common practice in school where observers select units of time within which to record observations but do not make a continuous record. The critical point is that behaviors such as attention, distractibility, and aggressivity can be defined and assessed in naturally occurring circumstances.

A time-sampling protocol for talk-outs in the classroom situation is shown in Figure 1. The target behavior, talking-out, conformed to the following criteria: (1) talking-out without the teacher's recognition, regardless of the speech content, and regardless of the teacher's response; (2) talk-outs must be audible to the observer or be inferred from the response of others following an observation of lip movements in the target child; (3) a 3-second pause between talk-outs constitutes two discrete occurrences.

The teacher's behavior code appears below the rating form and falls into five basic categories: looking; physical proximity; physical contact; verbal behavior; and no response. Raters observed the target child in

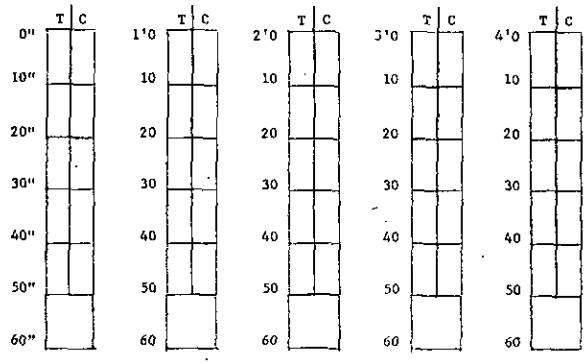

FIGURE 1. A classroom observation protocol. Teacher's observation code.

I. Looking
   a. L+ = smile; nod; wink; etc.
   b. L− = frown; gestures; head-shaking; etc.
   c. L^0 = orienting
II. Approach—Withdrawal
   a. A = closes distance
   b. W = opens distance
III. Contact
   a. C+ = pat; caress; etc.
   b. C− = restraining; shaking; grabbing; etc.
IV. Verbal
   a. V+ = praise and/or affection, e.g., "good," "That's nice"
   b. V− = critical and/or belittling. e.g., "You're not doing well," "That's unkind"
   c. V^0 = routine nature; nonthreatening, e.g., "What shall we do now?"
V. No Response
   a. N = responses not directed towards target child

10-sec intervals, noting the presence or absence of the child's (C) response and the teacher's (T) response. In addition, the observers worked on 5-min "on" and 5-min "off" cycles. Finally, a 10-sec free period was provided at the end of each observation minute to make further comments.

Suggestions for Research

There are no data based on such techniques in the context of exposure to chemical pollutants. Given that a behavioral technology now exists that can provide reliable and valid assessments of complex behavior, how might it be applied?

A research plan involving behavioral approach to assessment could entail a com-

bination of strategies: one an age-stratified sampling procedure, the other, a longitudinal procedure. The former permits an evaluation of how current lead body burdens correlate with appropriate variables. It cannot answer the crucial question of what legacy is left by early exposure, especially because the neonate seems to be extremely susceptible, perhaps because of its neurochemical immaturity.

The longitudinal strategy is critical because it permits the tracking of the same person, taking into account the individual's lead history. Longitudinal procedures are expensive, difficult to execute because of the mobility of subjects, and require an unusually relaxed and mature investigator because of the long delays between the inception of the research plan and its conclusion. Investigators in other areas, however, such as schizophrenia, have arrived at the same point, and today there are workers undertaking longitudinal research, in some cases, for 15 year periods. A longitudinal study, moreover, is the only procedure that will permit a monitoring of the "maturing-out" process observed in some children.

Epidemiologic data suggest sufficient natural variability in the body burden of lead to make an investigation of behavioral correlates reasonable. An initial sample of children drawn from communities with both old and new housing, so as to insure a full spectrum of lead levels, could be identified during the period, say, of 18 months to 2 years of age. Blood lead levels could be taken, and standardized home observations carried out. These latter observations could include measures of "activity" through open-field procedures, a technique which divides a particular setting into a grid and counts movements across squares, as well as spontaneous and situational speech samples which would yield some indication of the development of the verbal control over behavior. These children would be followed longitudinally into puberty, with the most critical data now flowing from the classroom environment.

The classroom is the optimal social environment for studying the socialization of children. First, with the exception of severe handicap or impairment, virtually all children enter the school system. Second, the behaviors of interest, i.e., distractibility, impulsivity, aggressivity, and so on, are likely to occur in this setting (*14*). In addition, cross-sectional experimental designs could be optimized by pairing children in the same classroom who differ with respect to blood lead levels.

In summary, we suggest to investigators interested in the consequences of asymptomatic lead absorption that they supplement traditional assessment procedures with techniques from applied behavior analysis, particularly in naturally occurring settings. Finally, while little has been said here, because of the emphasis on social interaction, there are also laboratory techniques that could be similarly adapted to provide valuable information about many other behavioral processes (*15*).

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