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Behavior Analysis and the Study of Human Aging

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As the population of older adults continues to rise, psychologists along with other behavioral and social scientists have shown increasing interest in this age group. Although behavior analysts have contributed to research on aging, the focus has been on applications that remedy age-related deficits, rather than a concern with aging as a developmental process. In particular, there has been little interest in the central theoretical questions that have guided gerontologists. How does behavior change with advancing years, and what are the sources of those changes? We consider the possibility that this neglect reflects the long-standing commitment of behavior analysts to variables that can be experimentally manipulated, a requirement that excludes the key variable—age itself. We review the options available to researchers and present strategies that minimize deviations from the traditional features of behavior-analytic designs. Our comments are predicated on the view that aging issues within contemporary society are far too important for behavior analysts to ignore.

Key words: gerontology, human aging, research methods

Recent years have witnessed a remarkable increase in the number of older adults within the American population. The latest census figures reveal that 13% of the population is now 65 years or older, and this number is projected to increase to 20% by 2030. In conjunction with this sheer increase in numbers, older Americans are living longer. According to a recent report (*Older Americans: 2000*), life expectancy at age 65 has increased 50% over the past century, from 12 years in 1900 to 18 years in 2000. These population trends are by no means limited to the United States, or even to Western countries. United Nations studies indicate that 1 of every 10 persons of the present global population is 60 years or older. This value is projected to increase to 1 in 5 by 2050 and 1 in 3 by 2150 (United Nations, Division for Social Policy and Development, 2000).

Within the United States, demographic changes are having wide-ranging social, political, and economic consequences that bear on the health and well-being of the individual. Although older adults are healthier and more active than previously anticipated, advancing years inevitably are accompanied by disabilities, failing health, and a variety of chronic diseases. The health status of the elderly is often regarded as more of biomedical than behavioral interest. However, there is growing recognition that behavioral processes make important contributions to the changes that accompany old age. Not only can behavioral techniques be used to rehabilitate deficient functioning, but the process of aging itself is under behavioral control in that several of the risk factors that are correlated with longevity (the acid test of an individual's health status) have behavioral origins: smoking, insufficient exercise, unhealthy diets, and failure to comply with the requirements of medical treatment (Rowe & Kahn, 1998).

Psychology as a whole has responded in numerous ways to the challenges posed by an increasing population of older adults. The American Psychological Association has a separate division devoted to the psychology of aging in which questions of both applied and basic interest are pursued. The organization also publishes a journal exclusively devoted to research on aging

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(*Psychology and Aging*), and it exhorts its clinical members to give special attention to the needs of older adults. Fueling this interest is increased federal funding for research and social services; private-sector agencies (e.g., the MacArthur Foundation) have become involved as well.

By comparison with these efforts, the behavior-analytic community appears to have lagged behind. One indication is the frequency of articles on aging that are published in the two flagship journals of behavior analysis—the *Journal of the Experimental Analysis of Behavior* and the *Journal of Applied Behavior Analysis*—in which interest in gerontological topics has remained low over the years. It also is difficult to find behavioral contributions published in such specialized aging journals as *Psychology and Aging* and the *Journal of Gerontology: Psychological Sciences*. This is not to say that behavior analysts have completely ignored aging. Beginning in the 1960s, various writers have pointed to the potential value of behavioral interventions that can improve the well-being of older adults (Baer, 1973; M. M. Baltes & Barton, 1977; Cautela, 1966; Hoyer, 1973; Lindsley, 1964), and discussions along these lines have continued (Burgio & Burgio, 1986; Carstensen, 1988; Perone, 1994; Skinner, 1983; Wisocki, 1991). Also, both the *Journal of Applied Behavior Analysis* in 1986 and *Behavior Therapy* in 1988 and 1997 have published special issues on aging, and there are interest groups on aging within the Association for Behavior Analysis and the Association for the Advancement of Behavior Therapy. Nevertheless, involvement by behavior analysts does not appear to have kept pace with the efforts of traditional psychologists. This impression is supported by recent reviews of the behavioral literature (e.g., Adkins & Mathews, 1999; Dupree & Schonfeld, 1998; Niederehe, 1997). Although note is taken of the progress that has been made, the articles stress that much more remains to be done.

The largest disparity between traditional and behavior-analytic contributions to the study of aging is in the area of basic research. There is an extensive biological and psychological literature that approaches aging as a fundamental life process. Within experimental psychology this approach compares performances of older and younger adults on laboratory tasks with the goal of examining such processes as memory, attention, and psychomotor speed (see Birren & Schaie, 2001; Kausler, 1991). Such efforts reflect the view that the central theoretical questions within gerontology pertain to the influences of an individual's developmental level on performance (cf. P. B. Baltes, Reese, & Nesselroade, 1977; Kausler, 1991). Specifically, researchers are concerned with describing changes in behavior with advancing years and determining the sources of those changes. The two potential sources are, of course, heredity and environment, and there has been considerable discussion of the potential contribution of each. It seems fair to say that conventional wisdom views aging as the product of a deteriorating nervous system and downplays the influence of the environment (Birren, 1974; Craik & Salthouse, 2000).

In contrast to these efforts within traditional psychology, research on aging rarely appears in the *Journal of the Experimental Analysis of Behavior* (for two exceptions, see Baron, Menich, & Perone, 1983; Baron & Surdy, 1990). Various reasons may be given for this neglect of the developmental side of aging. Perhaps the view has been too quickly accepted that aging reflects inexorable biological processes that are more or less immune to changes in the environment. Alternatively, the problem may be that behavior analysis is spread too thin, that the field lacks the personnel needed to address any and all questions of behavioral relevance.

In this article, we consider a different possibility. The dearth of behavior-analytic research on the variables that control aging may reflect a conflict inherent within the research traditions of behavior analysis. Our goal in this article is to spell out the conflict and to present strategies that minimize deviations from the usual features of behavior-analytic research designs. A number of the issues are fundamental to research on development in general (in this sense, our presentation is tutorial); in our view, they warrant wider discussion by behavior analysts. Throughout, our comments are predicated on the view that aging is too important an issue to be ignored.

Behavior-Analytic Research Methods and the Study of Aging

Within behavior analysis, the steady-state methods described by Sidman (1960) serve as the framework within which research is conducted. The fundamental features of the approach are well known: (a) Influences of experimentally manipulated variables are evaluated as they are reflected in the steady-state performances of individual subjects; (b) relatively few individuals are studied, but performances of each are examined at length; and (c) each individual's behavior is observed under a range of controlled conditions, thus establishing functional relations within the same individual. This combination of elements is well suited to meet the primary goal of a scientific analysis: to identify those aspects of the environment that control the specific performances of a given individual. The behavior-analytic literature attests to the power of this method in providing answers to a range of basic and applied research questions.

Special problems arise, however, when the experimental methods of behavior analysis are directed toward the study of aging. We have noted that by history and tradition, the central theoretical questions within gerontology concern the influences of an individual's age on performance. But unlike variables that are directly manipulated by experimental researchers, such as the magnitude of a reinforcer or the concentration of a drug, levels of the age variable cannot be imposed. If age is to be studied at all, then a person's age must be the one he or she brings to the research setting. No doubt, the same can be said about a host of other so-called *subject variables*, such as a person's gender, economic status, or personality, which have been neglected as well. In these and similar cases, researchers must select subjects in terms of the level in question (e.g., old or young, male or female, rich or poor).

It is apparent that concern with subject variables such as age is at odds with the research methods of the experimental analysis of behavior. The emphasis on control within behavior-analytic experiments places a premium on the study of individuals who share the same characteristics (e.g., all of the rats in an experiment might be male albinos of the same age). The procedure of holding subject variables constant has the distinct advantage of reducing variation that might complicate action of the experimental variables. The accompanying disadvantage is that the potential role of the subject variables is obscured. Thus, exclusive use of older adults as research subjects (or younger adults, for that matter) reveals much more about the experimental variables under study than about potential influences of the subject's developmental level. To determine the contribution of the individual's developmental level to performance, we must compare his or her performances to those of individuals who are at *other* levels (Baron & Perone, 1998).

Notwithstanding behavior analysts' reservations about defining independent variables in terms of selection rather than manipulation, subject variables are of considerable interest within the broad range of behavioral and social sciences. Traditional approaches not only accept subject selection as a legitimate alternative to manipulation but also deviate from behavior-analytic methods by focusing on group averages and inferential statistics rather than individual performances and functional analyses. These different approaches to research have isolated behavior analysis from traditional psychology and such disciplines as economics, political science, and education, ironically the areas that behavior analysts seek to inform and influence (Baron, Perone, & Galizio, 1991). Among other things, the differences in approach create barriers for obtaining Federal funding and publishing in nonbehavioral journals (Huitema, 1986). If behavior analysts are to make a wider contribution to an understanding of socially important issues—we have singled out aging in this regard—it seems essential that the strictures of the behavior-analytic approach somehow be reconciled with more conventional methods.

We might try to finesse obstacles to the experimental manipulation of age by stressing that age per se (i.e., the number of years since an individual's birth) is hardly the sort of event that can control behavior. Instead, the key factor is what has happened to the individual during the course of his or her lifetime, and such events potentially can be manipulated (Baer, 1973; Sidman, 1990). But as a practical matter, both the complexity and the extended time course of such influences stand in the way of effective study. Within gerontology, recognition that chronological age is an imperfect way to characterize developmental status has furthered the view that a person's age is better defined by the efficiency of his or her physiological or behavioral processes, a person's so-called "functional age" (Kausler, 1982). Unfortunately, efforts to classify people in terms of their functional age have not progressed to the point at which there are generally accepted standards of behavioral efficiency. Moreover, differentiation of individuals on the basis of functional rather than chronological age does not solve the problems involving variables that can only be targeted by selection.

To summarize, the conclusion seems inescapable that a comprehensive analysis of the aging process requires more than the study of the performances of older adults. To determine the contribution of an individual's age to performance, the logic of the experimental method requires that findings be evaluated against a developmental baseline: performances of individuals at other points along the age continuum. We might consider using observations of the same individual as the baseline, but the slow progression of change during the adult years is a major obstacle. The alternative, seen frequently in traditional research on aging, is to use data from other subjects, most often young college students. In other words, the performances of the younger subjects are taken to reveal how the older adults might have behaved in their own younger days.

Cross-Sectional and Longitudinal Research Methods

Discussions of research methods within gerontology are, with rare exception, conducted within a group-statistical framework, that is, research designs in which groups of subjects are compared and conclusions hinge exclusively on the results of inferential statistical tests (e.g., see Kausler, 1991; Salthouse, 2000; Schaie, 1977). In this section we review gerontological research methods from the vantage point of the behavior-analytic researcher. In so doing, it is important to remember the shared features of the group-statistical and steady-state approaches. Whatever their differences, the ultimate goal is the same: to make valid inferences about control by independent variables (Baron & Perone, 1998).

Comparisons of different groups constitute what is usually referred to as *between-groups* designs. The distinguishing feature is that different subjects are randomly assigned to the different groups, a tactic designed to increase the likelihood that average levels of uncontrolled background variables will be similar. By comparison, random assignment of subjects is precluded with selected variables such as age. Instead, data are collected from age-differentiated groups, and the term *cross-sectional* design is used. Although performance differences seen in cross-sectional studies may be attributed to the age variable, they also may reflect any of the countless other ways that the groups differ. These other influences, so-called *cohort effects*, reflect the different life experiences of different generations. An individual's particular age is correlated with a given level of schooling, nutrition, health care, and parenting style, in other words, with all of the various ways in which environments have changed over the years. Obviously, cohort effects are a major complication when cross-sectional methods are used to study age-correlated changes in behavior.

Researchers sometimes turn to more sophisticated versions of cross-sectional designs to cope with cohort effects. *Sequential designs*, for instance, attempt to assess the contribution of cohort effects by replicating between-groups age comparisons in the future, that is, with different cohorts. If results are similar with two new cohorts of younger and older individuals, then confidence is increased that age, rather than some variable correlated with age, is the critical factor. Unfortunately, if results are different, one is left in the dark about the source of the difference. Less ambitious in terms of time and effort are cross-sectional procedures that match cohorts in terms of potentially confounding variables (e.g., health status), or procedures that statistically adjust scores to compensate for the confounding variables. However, none of these strategies is completely satisfactory, even from the standpoint of the group-statistical researcher (Kausler, 1991). For example, procedures that match older and younger subjects in terms of educational level may reduce the representativeness of the older sample for the population as a whole.

Yet more fundamental interpretative problems are highlighted by Schaie's (1967) distinction between "age changes" and "age differences." Schaie pointed out that insofar as the goal of the study of aging is a developmental one, cross-sectional comparisons cannot reveal such information directly. Thus, cross-sectional comparisons provide information about differences between individuals of different ages rather than descriptions of how a given individual changes during the course of his or her lifetime. Information about behavior change demands *longitudinal designs*, that is, procedures in which the same individual is repeatedly observed at different ages.

When cross-sectional designs are used to reach conclusions about change, they can yield artifactual results. Woodruff-Pak (1988) illustrated this point with respect to children's physical growth. When gauged in terms of cross-sectional findings, increases in height throughout childhood follow a smooth, negatively accelerated pattern. By comparison, longitudinal studies reveal growth spurts in individual children and other deviations from the average trend. Because these deviations occur at different ages for different children, they are concealed by the cross-sectional averages (averaged longitudinal data create the same problem). The possibility of these types of individual differences is especially relevant to processes of adult development insofar as different life experiences over the years should make older individuals more and more diverse. As a consequence, central tendency measures of group behavior will become increasingly less representative of the individual members of the group (Birren & Schaie, 2001).

The repeated observations that characterize longitudinal designs may appear to be a straightforward way to examine age changes. However, even under the best of circumstances the method is accompanied by its own set of problems. For example, biases may be introduced into the analysis because some subjects' data are lost through attrition, and repeated observations (e.g., practice effects) have independent influences on performance. The method also cannot control for variables external to the research that may accompany advancing age, such as changes in the sociocultural climate. This last drawback forms the basis of what has been referred to as the *time of measurement problem,* the possibility that longitudinal changes are linked to the particular point in time at which observations are made. This interpretative problem is sidestepped with cross-sectional procedures because all of the data are collected at the same point in time.

Schaie (1977) expressed the dilemma faced by the researcher. In cross-sectional procedures, subjects of different ages are born at different times. Although the time of measurement can be held constant, age and cohort are confounded. In longitudinal procedures, all subjects are born at the same time, but the cost is that age changes and time of measurement are confounded. Thus, the developmental researcher is presented with formidable interpretative problems, regardless of the procedure that is followed.

Longitudinal approaches, with their assets and liabilities, have close links to behavior-analytic research methods. Steady-state approaches require that the different levels of the experimental variable be imposed at different times, and in this sense steady-state methods are intrinsically longitudinal. A key aspect of longitudinal methods is that the individual's own performance, rather than normative data obtained from others, is the baseline against which developmental changes are assessed (Sidman, 1986, 1990). Within this framework, the method provides a basis for the introduction of variables that might modify an individual's rate of development. However, we should not overlook some significant methodological barriers. Variables that play critical roles in determining an individual's rate of development originate within complex environments that are not easily brought under experimental control (e.g., a child's home environment). Equally important are the extended time periods required for the variables to have their effects.

From a practical standpoint, the longitudinal strategy is most useful for the study of children because early development is characterized by rapid changes. For the infant, a span of a few months can reveal major differences in behavioral capability; the time span needed to detect differences during later stages of child and adult development increases progressively. No doubt, the slow rate of change is one reason why cross-sectional studies of aging so often contrast college-age students and retirement-age adults, a span of 40 or more years. Perhaps it is not surprising that longitudinal studies of human development are infrequent and most often directed toward the behavior of children (for a behavior-analytic example, see Hart & Risley, 1995). Occasional efforts to conduct longitudinal research across the life span have been truly heroic episodes in the history of psychology (Terman's life-span study of gifted children required several generations of researchers to complete; see Holahan, Sears, & Cronbach, 1995).

The considerations raised in this section clarify why cross-sectional designs have been, and undoubtedly will continue to be, the predominant method for research on the aging process. Behavior analysts who are interested in studying the long-term variables that control the aging process appear to have little choice but to rely heavily on cross-sectional analyses as well. A counterpart to this concession is that behavior-analytic researchers not only must incorporate a selected variable into the research design but also must contemplate adoption of inferential statistical procedures to establish the reliability of group differences as a function of age. The usual data-analytic procedures of behavior analysis are better suited to handle the reliability of differences between steady states of

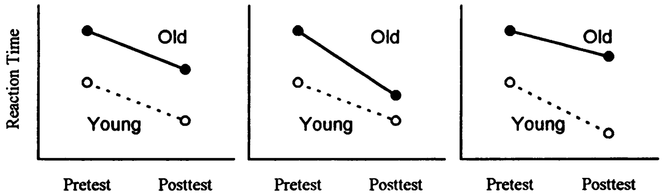

Figure 1. Hypothetical data depicting three possible effects of operant training on the reaction times of younger and older adults.

the same individual than differences between the aggregated behaviors of groups of individuals (Baron & Perone, 1998).

Interactions

We noted that cross-sectional comparisons cannot conclusively establish age as the variable that controls age performance differences. Indeed, research using this method is as much correlational as experimental (hence the label *quasiexperiment*). In this section we will show that cross-sectional comparisons can, nevertheless, provide a foundation for research that minimizes deviations from more traditional behavior-analytic methods. The essential feature of the approach is the examination of interactions between age and other variables that can be experimentally manipulated (Kausler, 1991). In so doing, two features of behavior-analytic methods are retained without modification: first, the focus remains on the individual organism, and second, observations under a given condition are of sufficient duration to establish steady-state performances.

Identification of interactions requires a factorial design, that is, a design that incorporates the variables involved in the potential interaction. For studies of aging, the simplest case is a 2 × 2 design in which subjects of two ages (Factor A) are studied under two levels of some variable that is manipulated within a subject (Factor B). To provide a concrete example, Baron, Menich, and Perone (1983) contrasted reaction times of younger and older men (A1 and A2 in the 2 × 2 design) at two points in the experiment: first, prior to operant training (B1) and then following training with a procedure in which reinforcement required rapid responding (B2). For both levels of the within-subject variable (B), conditions were terminated only when stable performance had been observed.

Three possible outcomes of such an experiment are displayed in Figure 1. The data in the left panel show results when age differences in reaction times are not influenced differentially by training. Although the younger subjects are faster, both younger and older subjects profit equally (A1-B1 = A2-B2), that is, the functions for younger and older subjects are parallel. In the case shown in the middle panel, the older subjects profit more than the younger ones with the consequence that the age difference is reduced (A1-B1 < A2-B2); that is, the functions converge as a consequence of training. Finally, the right panel shows the outcome when the older subjects profit less from training so that the age difference increases (A1-B1 > A2-B2); that is, the functions diverge.

In actuality, Baron et al. (1983) obtained results that were consistent with the pattern shown in the middle panel, thus showing that reinforced practice can reduce age differences. Findings of this sort are of general interest for an understanding of aging. They not only point to a way of remediating speed-related deficits in older adults but also support theoretical interpretations of age deficits in terms of disuse. At least part of the reason why older adults perform poorly in laboratory experiments is that they are out of practice (Baron & Cerella, 1993).

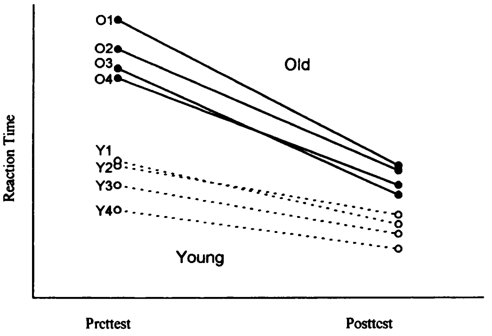

Figure 2. Hypothetical data depicting the effects of operant training on the reaction times of individual younger and older adults.

Designs that combine selected and manipulated variables are referred to as *mixed designs*. Their use by behavior-analytic researchers also calls for mixing different procedures for establishing the reliability of differences. Although inferential statistics may be needed to evaluate the between-groups variable (age), steady-state comparisons can be used to establish differences in the manipulated within-subject variable (reinforced practice). The latter effect is amenable to the usual graphic analyses. The problematic issue pertains to assessing the third term in the analysis, the interaction between the selected and manipulated variable (age × practice). One approach is to employ conventional statistical analyses (e.g., analysis of variance), which, with their strengths and weaknesses, routinely assess not only the main effects of variables but also their interactions. However, when a within-subject manipulated variable is investigated with steady-state procedures, the researcher need not abandon behavior-analytic procedures that can reveal changes in performance at the level of the individual subject.

To illustrate how one might proceed, the results in the middle panel of Figure 1 have been expanded in Figure 2 to display performances of 8 individuals, 4 younger and 4 older (to simplify the presentation, hypothetical data are used). Consistent with the averages for the groups, the individual functions in Figure 2 all have negative slopes, thus showing that the reductions in reaction times generally were replicated across the 8 subjects. These steady-state data also can be used to assess the reliability of the age × practice interaction. In this regard, it can be seen that the slopes for the 4 older subjects are consistently steeper than those for the 4 younger subjects.

The statistically inclined reader might question the general finding that reaction times decreased with practice. How can we be sure that the changes are reliable? One answer, when steady-state methods have been used, is that the changes in steady states for a particular subject establish the change as reliable for that individual, at least. In addition, this and similar questions can be answered in terms of individual performances by substituting simple probability tests for the complexities of analysis of variance. Thus, the odds of observing the same pattern in eight of eight independent events, that is, in all 8 subjects, are less than 1 in 200, and the odds that slopes for the 4 older subjects will be consistently steeper than for the 4 younger ones (the age × practice interaction) are less than 3 in 100 (p = .028; Mann–Whitney U test). We emphasize that for the present data, at least, these various effects are self-evident, and statistical evaluations seem to be an unnecessary complication.

A feature of the functions in Figure 2 is that despite the older individuals' greater degree of improvement, they generally were slower; there is a main effect of age. As we noted earlier, age differences can be correlated with any one of a number of differences that exist between cohorts. The potential impact of such differences was reduced in the Baron et al. (1983) study by matching the older and younger subjects, insofar as possible, for such obvious factors as health status and educational level (the older adults were auditing classes at the university). Also, we hoped that the repeated observations needed to observe steady-state behavior would counteract possible age differences in performance anxiety and familiarity with laboratory procedures. Insofar as one can be reasonably confident that these and all other potential cohort differences were removed from the picture, any residual difference points to age per se (more specifically, age-correlated biological changes) as the source of the controlling variable (Kausler, 1991). Results that show continued age differences despite matched groups support the conventional wisdom that even healthy, active older adults are not immune to behavioral deficits because of the inevitable physiological changes that accompany aging (Birren, 1974; Salthouse, 2000). The methods of behavior analysis provide a powerful tool for testing the limits of such interpretations.

To summarize, mixed designs and the analysis of interactions between age and experimentally manipulated variables represent a point of convergence between behavior-analytic and cross-sectional designs. In his exposition of the "experimental psychology of aging," Kausler (1991) emphasized that the task of the psychologist of aging is not only to identify age per se as the source of age differences (vs. cohort differences, for example) but also to identify those variables that are responsible for declines in performance—what he called *age-sensitive* variables. Put in more behavioral terms, an individual's age might be considered an *establishing operation* that modulates the effects of reinforced practice.

An interpretation of age as an establishing operation falls within the framework provided by Kollins, Newland, and Critchfield (1997) in their discussion of human sensitivity to reinforcement. To improve control, they proposed that manipulations of reinforcement variables be conducted within the context of information about subject characteristics. For example, when money is used as a reinforcer, subject-to-subject variability might be reduced by screening subjects in terms of their financial circumstances. By comparison, the approach we advocate treats the establishing operation of the subject's age as a variable in its own right, one that can be examined in terms of its interaction with the manipulated variables of the behavioral experiment.

Conclusion

Although behavior analysts have committed themselves to the development of a complete science of human behavior, research has favored those issues that are amenable to study by manipulating relevant variables. If behavior analysis is to join the search for the sources of age-related changes—and we believe it should—then behavior-analytic research must also incorporate variables that can only be approached by selection, such as the subject's age. In our presentation, we have proposed ways in which this might be accomplished while many of the techniques that are the hallmark of behavior-analytic research methods are preserved.

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