Bayer-Symposium VII
Brain Function in Old Age, 164-187 (1979)

The Critical Importance of Appropriate Methodology in the Study of Aging: The Sample Case of Psychometric Intelligence*

P. B. Baltes and S. L. Willis

Summary

A variety of methodological desiderata for gerontological research are identified and discussed in the context of the developmental study of psychometric intelligence in old age. This area of research offers a good scenario because there is current controversy in data and theory involving the extent (onset, universality) of intellectual decrement in old age. It is argued that this dialectic is largely a reflection of growing recognition and application of novel methodological perspectives. A first set of methodological issues presented deal with proper assessment of intellectual behavior in older adults (problems of validity, of obtaining information on intraindividual variability and plasticity, and of separating factors of performance from those of competence). A second set of issues involves questions of developmental design aimed at valid identification of ontogenetic (intraindividual) life-span change and of developmental interindividual differences. These issues are discussed as they involve the use of cross-sectional, longitudinal, and cohort-sequential methodology. A third set of methodological issues relates to explanatory-causal work on intellectual aging and the role of intervention paradigms. As a framework for explanatory research, a multicausal model of influences on aging is presented. This model identifies three systems of influences (normative age-graded, normative history-graded, non-normative critical life events) which control the life-span development of intelligence. Such a multicausal and interactive view requires a set of methodologies which minimizes the role of chronological age as the prime carrier for causation. In addition, process-oriented intervention research is discussed which focuses explicitly on the study of the conditions for varying (differential) aging. During the last decade, emerging application of the methodological desiderata outlined has resulted in a major reevaluation of the traditional evidence on intellectual aging which had highlighted decline as the primary and universal characteristic. Although the available evidence is not yet rich enough to justify a precise conclusion, it appears that intellectual aging in current cohorts is much more plastic and heterogeneous than past research with limited methodologies (such as cross-sectional age comparisons with static youth-oriented measurement instruments) would have suggested. It is speculated that similar methodology-induced deficits in knowledge about psychological aging might exist also in other areas of gerontological research.

*This chapter was completed while Paul B. Baltes was a Fellow at the Center for Advanced Study in the Behavioral Sciences at Stanford, California. This fellowship was supported, in part, by a grant from the National Science Foundation (BNS 76-22943 Ao2). Grant support from the National Institute on Aging (5Ro1AG0040) for a project entitled "Cognitive Modifiability in Aging" to the Pennsylvania State University and Paul B. Baltes and Sherry L. Willis (co-investigators) is also acknowledged. Furthermore, a discussion with Matilda W. Riley regarding the multicausal model of influences proposed was helpful.

Background and Objective

It is generally accepted that theory and methodology need to go hand in hand in order to advance a field. It is less common to find persuasive examples. Research on the development of intelligence (intellectual performance) in adulthood and old age is such a sample case. This is not only true for the past, but the intricate relationships between theory and methodology is played out as well in present research on the topic. In fact, much of the current dialectical tension in the field is either the result of data collected by novel forms of methodology (such as the use of cohort-sequential methods and the use of behavioral intervention designs), or the reflection of different methodologies associated with distinct conceptual belief systems held by investigators.

Because of the concern with methodology, it is not the purpose of this chapter to present a reasoned evaluation of the substantive evidence on adult and gerontological intelligence. In fact, largely for the recency of the research, the dialectic generated by the evidence from different research quarters has not yet resulted in a new level of integrated understanding. On the question of intellectual decline, for example, fairly separate positions and views of the available data on adult intelligence continue to exist (e.g., Horn, 1978; Horn and Donaldson, 1976, 1977; vs. Baltes and Schaie, 1976; Schaie and Baltes, 1977; Baltes and Willis, 1979; Labouvie-Vief, 1977).[1] However, it is clear that the evidence now dictates concerted application of methodologies distinctly suited to understand intellectual aging in its developmental, differential, and plastic aspects.

[1]The thoughtful review chapter by Botwinick (1977) presents perhaps the best reasoned case for maintaining a position which includes decline in intellectual abilities (small and differential in late adulthood, general and large in old ages) as the major feature of intelligence in adulthood and old age. For the data base covered by him, Botwinick's interpretation has many strengths. However, compared with our view (e.g., Baltes and Willis, 1979), Botwinick does not pay sufficient attention to issues of aging-fair measurement and questions of plasticity. These issus are discussed in later sections of this chapter.

For the present purpose, methodology is defined as identifying variations in research strategy dealing with aspects of data collection, experimental design, data manipulation, and data interpretation. Research strategies, of course, do not stand serene and independent at some high level of abstraction. On the contrary, the formulation and choice of research strategy is, at least in part, related to metatheoretical assumptions and the existing corpus of theory in a given field. A general discussion of the relationship between theory and methodology, however, is beyond the scope of this chapter. The interested reader is referred to such general publications as by Kuhn (1970) or Overton and Reese (1973). In the area of adult and gerontological intelligence, recent observations by Botwinick (1977), Labouvie-Vief (Labouvie-Vief, 1977; Labouvie-Vief and Chandler, 1978), and Schaie (1978) are particularly helpful as a beginning source.

The objective of this chapter, then, is to trace how application of distinct methodologies is shaping our knowledge about adult and gerontological intelligence. This applies both to what we know and what we do not know. Specifically, with a focus on psychometric intelligence, it will be shown how application of cross-sectional methodology, administration of youth-centered assessment devices, and use of static conceptions of intelligence has contributed to a picture of gerontological intelligence which is one of normative decline in intellectual performance. Conversely, it is argued that application of alternative research strategies, involving variations of longitudinal methodology and intervention design, aimed at studying variability (limits) rather than average performance, have resulted in new evidence. This evidence draws attention to a new set of attributes, such as plasticity, interindividual heterogeneity, and the role of history-graded and non-normative life events, which need to be considered when formulating a comprehensive theory of intelligence in adulthood and old age.

Adult and Gerontological Intelligence: Issues in Assessment

The following sections are aimed at summarizing emerging evidence on the development of intelligence during adulthood and old age. The framework will be one of historical and methodological comparison. A primary goal is to identify important dimensions of methodology and its interaction with substantive theory. There are several methodological issues related to assessment (description) of intelligence which are not considered in this brief chapter, such as the questions of multidimensional versus unitary measurement, of cohort-fair measurement, of the spacing of repeated observation, or of the issue of differential rates of change such as those associated with terminal drop (e.g., Baltes and Labouvie, 1973; Botwinick, 1977; Davies, 1977; Horn, 1978). The issues selected are seen as those deserving most attention in the present context.

Measurement of Intellectual Behavior

Intelligence has been defined in many ways (e.g., Resnick, 1976; Botwinick, 1977). In general, two major approaches to the study of intellectual behavior have been identified. Historically, the psychometric approach has been the first. Psychometric concepts of intelligence have been largely developed in connection with intelligence testing, prediction, and the concept of human abilities (e.g., Thurstone, 1938; Guilford, 1967; Cattell, 1971; Horn, 1978). A second major approach is related to the study of intelligence as cognition, involving processes of learning, memory, information processing, and problem solving (Kintsch, 1970; Rohwer et al., 1974). Throughout the history of research on intelligence, efforts have been made, though not with overwhelming success, to produce convergence between these two major lines of research on intelligence. The recent books by Resnick (1976) and Sternberg (1977) are such examples.

The present chapter is restricted to one major approach to the study of intelligence, that of psychometric intelligence. Selecting the psychometric approach to intelligence is less the result of a conceptual preference by the author for that strategy, than a result of the fact that many methodological issues have been identified and clarified in that arena of research.

Concept of Intellectual Abilities

The psychometric tradition has produced a number of fairly reliable and valid statements about intelligence (see Cattell, 1971; Horn, 1977, 1978 for reviews). The formative thought of the psychometric tradition is related to the notion that intelligence can be observed in its product (performance). Subsequently, these products can be organized to yield a parsimonious model of intelligence. The general strategy is to ask persons to solve a large variety of intellectual tasks which make up so-called intelligence tests. These multitask performances, collected from many individuals, are then examined as to their interrelationships (structure). The goal is to identify a number of basic dimensions (factors, abilities) of intelligence. Factor analysis, in its various forms has usually been used to accomplish such a goal.

Using primarily such an interindividual-differences and covariation-oriented approach, a number of structural models of intelligence have been developed. It is important to realize that, for the most part, these psychometric models are based on observations on young adults as subject populations and on tasks which show much resemblance to the content of academic subject matter. Examples are the structure-of-intellect model developed by Guilford (1967), or the fluid-crystallized model of intelligence constructed by Cattell and Horn (Cattell, 1971; Horn, 1978).

These structural models of intelligence yield at least three pieces of information: a) a set of intelligence factors or abilities, b) information on the relationship (structure) among these ability factors, and c) tests which can be used to measure the level of performance of individuals on these abilities (factors). Depending on the level of test construction, there is also associated with each structural model and its tests, a body of knowledge about concurrent and predictive validity. This body of knowledge speaks to the various applications which tests can be put to in applied and clinical settings.

Abilities in Old Age: Which Criteria of Validation?

When research on adult and gerontological intelligence began, it was common practice to use existing psychometric tools as a framework to define and measure intelligence. However, the fact is that this strategy is a shortcut.

Earlier psychometric research on intelligence with children and young adults was based on careful analyses of the tasks and settings related to intellectual behavior in those age groups. The historical giants of the field of psychometric intelligence, such as Binet and Thurstone, spent considerable time in developing appropriate task material and age-appropriate models of intelligence. Researchers interested in late adulthood and old age, however, have a tendency to simply apply the methods of psychometric intelligence as they had been developed previously for younger age populations. Thus, we find longitudinal studies into late adulthood being based on the Army Alpha tests developed largely in the context of the military services or on the Primary Mental Abilities Tests constructed for research with college students. Note that such intelligence tests, in terms of their content and predictive validity, were primarily designed for the purpose of forecasting successful performance in academic and professional settings characteristic for early adult life.

As a consequence, as argued also by Schaie (1978) and Schaie and Schaie (1977) and earlier by Pressey, what we know about psychometric intelligence in the older adult is based on instruments and models developed for the young. In other words, we know how to compare the older person with the young in youth-oriented tasks and settings. But we have relatively few instruments that would tell us much about the unique nature of intellectual behavior and its predictive validity in the older adult. Although this critical view of existing measurement instruments has been expressed rather persuasively some time ago (e.g., Deming and Pressey, 1957), the effort invested into counteracting this deficiency has been amazingly meager. Moreover, some of the most aggressive proponents of a trait conception of intellectual aging, often associated with positions of marked decline (e.g., Horn, 1978; Horn and Donaldson, 1977), base their own research and interpretation almost exclusively on the use of test instruments developed in the context of young adults, where academic performance served as the major validation criterion.

If a representative assessment of gerontological intelligence is at stake, a youth-oriented approach does not appear defensible, at least not as the primary strategy of assessment. What is imperative in future research on adult-gerontological intelligence is to make the intellectual behavior of older adults and their ecologies the guides for content, predictive, and construct validation. Linking the intellectual behavior of older persons to

that of younger ones, using youth-oriented instruments, will remain a part of our search for life-span knowledge and life-span bridges connecting intellectual development. However, in order to produce balance in assessment methods and models of intelligence, future work on gerontological intelligence will need to be life-span and old age-centered. It will need to consider problems of task analysis and validation which reflect the intellectual demands for the older person and the recognition of multiple-age (or developmental) and multiple-setting criteria as references for validation (Schaie, 1978).

For example, if intelligence is a construct aimed at measuring successful adaptation in particular settings and task situations which are changing as life-span development progresses (see also Clement, 1977; McClelland, 1973), what are the unique settings and tasks related to the intellectual behavior of the older person? What are the intellectual tasks of advancing adulthood and how are these tasks related to the task systems of earlier life? To what degree is it perhaps necessary for the older adult to unlearn (rather than passively forget) knowledge and skills acquired in the first part of the life course? It seems fair to conclude that, on this score, research on gerontological intelligence is truly in its infancy, some notable exceptions (e.g., Gardner and Monge, 1977; Schaie, 1977-1978; Clayton and Birren, 1980, in preparation) notwithstanding.

Emerging research by Clayton and Birren (1980) on wisdom can serve as an illustration of relevant inquiry. In exploring possible dimensions of salient intellectual behavior in the elder, Clayton and Birren develop a number of propositions about the concept of wisdom as an aging-related emerging property of intelligence. At present, their work is largely in the stage of conceptualization, an important and often sorely neglected step in gerontological research. However, Clayton and Birren have already specified some salient features of wisdom which distinguish its structure and function from that of traditional intelligence. For example, they see wisdom behavior as involving not only cognitive, but also affective components, and as requiring an integration of personal knowledge about life-span development for which "being old" is a necessary condition. Similarly, Schaie (1977-1978) advances a model of cognitive behavior which specifies five life-course periods of cognition (acquisitive, achieving, responsible, executive, reintegrative), only the first two of which are part of traditional childhood and adolescent intelligence. As a consequence, Schaie argues that existing psychometric techniques and models of intelligence are restricted largely to the first two periods (acquisitive, achieving) of his five-stage sequence, and that novel technologies are necessary for the study of cognitive development in midlife and old age.

Average Performance (Trait) versus Intraindividual Variability (Plasticity)

Trait versus Plasticity. A second theme of the dominant approach to the study of psychometric intelligence in late adulthood has been an extraordinary preconception with viewing abilities as largely invariant and fixed, "as attributes that have many of the properties of a trait, as this concept is used in general biology. That is, ... defined as an enduring characteristic by means of which one person can be distinguished from another" (Horn, 1977, p.140). This general trait approach is reflected in the usual observational scheme associated with psychometric intelligence which involves an average performance per individual based on a static, single-occasion measurement of intellectual performance in a variety of tasks. Note that averaging is based on averaging of tasks given at one occasion, rather than on consideration of a developmental (longitudinal) time continuum or the individual's adaptive capacity to different life situations. An additional feature of age-comparative research on psychometric intelligence has been the fact that assessment has been conducted under standard fixed conditions, with all persons participating in the same observational procedure, independent of their life (pretest) history.

Obviously, such an average performance- and trait-oriented approach does not lead to information on the *range* (limits) of performance in psychometric intelligence. Its implied premise is that single-occasion observations on a variety of intellectual tasks (with testing conditions held constant) lead to general information about the performance of an individual. This can be true only for the limited case represented by the testing situation. Recognizing this limitation is particularly important, if assessment of intelligence is not only seen as an indicator of performance, but of capacity or potential. In fact, in the gerontological literature, performance measures in static situations are often taken as measures of what the elder is capable of doing in principle (intelligence as capacity or competence). This is a highly questionable inference (see also Botwinick, 1977), because it involves generalization from performance in test situations to unobserved settings, and to possible treatment benefits, thereby neglecting intraindividual variability.[2]

It is rarely recognized that information on intraindividual variability and on the conditions for such variability (e.g., as a function of pretest history or concurrent treatment conditions) is an important ingredient to a comprehensive theory of psychometric intelligence (Willis and Baltes, 1979). Historically, the concept of testing the limits had been introduced exactly for the purpose of obtaining information on intraindividual variability or the possible range of performance. The available evidence on gerontological intelligence, however, is thoroughly lacking in knowledge about plasticity or intraindividual variability, whether seen in a short-term (concurrent) or long-term

[2]In the literature on abnormal cognition in geriatric medicine, the issue of separating competence from performance deficits has a counterpart problem. A distinction between "true" senility, presumably biologically-based, and various forms of pseudosenilities is discussed by medical researchers and practitioners (e.g., Libow, 1977). The methodological requirement of testing and studying the limits of performance presented in this chapter applies equally well to that forum of research and diagnosis.

(developmental) framework. Short-term or concurrent plasticity refers to the range of performance which a given individual can display at any given developmental time, if subjected to different treatment conditions. Long-term or developmental plasticity refers to range of performance, not at any given point in time, but in regard to the nature of developmental functions (Wohlwill, 1973) or developmental behavior-change processes as they extend over longer segments of the life course.

Thus, we do not know what the aged person could do. All we know is what the aged person does, if he/she lives in the context of the current social ecology, if she/he is not exposed to varying biological and environmental conditions (whether construed as facilitative or interfering) before assessment begins, and if she/he is asked to participate in one mode of assessment, that which is dictated by procedures and models developed in the life context of the yound adult. Without such evidence, it is not possible to make statements about aspects of intellectual potential, but only, to use a statistical analogue, about a "fixed-level" of performance delivered in a highly specific setting. Baltes and his colleagues (Baltes and Willis, 1977; Baltes and Danish, 1980) discuss the importance of intervention research for exploring the possible range of psychological aging in greater detail and in a more general context.

Research on Plasticity. There is beginning research to counteract the traditional preconception with average performance (trait) in psychometric intelligence (see Labouvie-Vief, 1976; Baltes and Baltes, 1977; Willis and Baltes, 1978, for reviews).

On a descriptive level, a first line of work emphasizes the existence of large interindividual differences as aging unfolds. Related to this approach is work concerned with examining the interactive effects of individual life histories and intellectual performance in the adult (Charles, 1973; Schoenfeldt, 1973). A recently published study by Kohn and Schooler (1978) is an excellent methodological illustration of such an approach linking, in an interactive framework, intellectual performance (flexibility) in adults to the substantive complexity of their occupational work settings. While Kohn and Schooler (1978) find remarkable stability in intellectual flexibility over a 10-year period, they also report a substantial longitudinal effect of the complexity of the work environment on subsequent intellectual development (in addition to a strong reciprocal, though lagged effect from intelligence on the substantive complexity of work).

This somewhat indirect evidence on intraindividual variability (by making interferences from interindividual differences) is supplemented by experimental research on learning and memory dealing directly with intraindividual variability (e.g., Craik, 1977; Schaie, this volume). In microanalytic laboratory situations, researchers in that area have examined the effect of various treatment conditions (such as warm-up, pacing, instructional variation) on cognitive performance. Such research has given us solid information on the intraindividual range (plasticity) of performance, however, that information is restricted to relatively small variations of time (concurrent plasticity).

The most directly line of inquiry is based on intervention research. Intervention research is aimed at examining the role of various behavioral intervention programs and so-called ability-extrinsic performance factors (see Labouvie-Vief, 1976; Baltes and Baltes, 1977; Willis and Baltes, 1978; Denney, 1979, for reviews) affecting the intraindividual range of intellectual performance. In general, the relevant data are not yet rich enough to warrant a firm conclusion. However, it appears that first results are rather promising in attesting to much more intraindividual plasticity in gerontological intelligence than acknowledged before by most researchers in the field.

Considering the magnitude of such preliminary findings on the responsiveness (plasticity) of older adults to various performance-enhancing treatments and on the impact of individual life histories, it becomes apparent why research on the conditions for intraindividual variability in intellectual performance is so critical for an understanding of old age. If, for example, the hypothesis (Labouvie et al., 1974) is correct that the majority of older persons live a) generally in a cognitively deprived environment and b) also in an environment which de-emphasizes youth-oriented tasks involving academic and occupational achievement, then our current assessment of the intellectual capacity of older persons by means of psychometric instruments is also terribly deficient and aging-biased on this score. The current assessment focus is on static assessment of intellectual behavior in specific settings, settings which are likely to be nonrepresentative or even dysfunctional for the elder. Appropriate assessment should include examining the range of intellectual behavior and of the conditions under which performance variability is obtained.

Assessment of Developmental (Aging) Change in Intelligence

Another set of major issues in methodology which has received much attention in the recent decade deals with questions of design and control necessary to achieve valid measurement of developmental changes in life-span development. In addition to the need for experimental designs aimed at a proper explanatory analysis of aging processes (e.g., Baltes and Goulet, 1971; Birren and Renner, 1977), a number of specific propositions have been advanced regarding the descriptive identification of aging phenomena. Within developmental psychology, many of these developments have occurred in the context of the study of psychometric intelligence.

Longitudinal and Cohort-Sequential Designs

First, the relationship between various forms of age-developmental methods of data collection, such as the cross-sectional and longitudinal method, have been clarified (Schaie, 1965, 1970; Baltes, 1968; Schaie and Baltes, 1975; Baltes et al., 1977; Nesselroade and Baltes, 1980). It is now recognized that the basic descriptive task of any developmental approach (including

the study of aging) consists of the proper identification of two components of variability: 1) intraindividual variability, and 2) interindividual differences in intraindividual variability. Unless designs permit the clear separation of these two components of variability, misidentification of developmental change and of developmental differences in change results. In fact, up to a few years ago, much of the literature on intelligence in old ag has suffered from this methodological flaw.

For a given birth cohort (individuals born at a specified time, say in 1900), it is only the longitudinal method which can provide for direct information on both intraindividual change and interindividual differences in such change. In a strict sense, the cross-sectional method is never an appropriate substitute for longitudinal (repeated measurement) investigation. However, the situation in aging research is further complicated due to possible biocultural changes affecting the course of life-span development for individual cohorts.

If such biocultural changes exist, single-cohort longitudinal information on change is not sufficient. Developmental designs need to consider two additional components of variability: 3) between-cohort differences in intraindividual variability, and 4) between-cohort differences in interindividual differences in intraindividual variability. As a consequence, if biocultural change in a given behavior is obtained, findings from single-cohort longitudinal studies cannot tell the entire story about individual aging. The reason is that a single-cohort longitudinal study is but a sample from a population of cohort-specific longitudinal studies, and therefore, its results cannot be generalized to other cohorts. To what degree generalization from the life-span development observed in one cohort to another is possible, is a matter of empirical demonstration.

In psychology, and especially in the area of psychometric intelligence, it has been established that such generalization across cohorts is not possible for current aging cohorts living in the Western world. Cohort-sequential studies, for example, by Schaie and his colleagues (e.g., Schaie, 1979) in the United States, or by Rudinger (1976) in Germany, the latter based on data from the Bonn Longitudinal Study, represent powerful and persuasive cases. Further research on the role of cohort effects in the study of life-span development is summarized in Baltes et al. (1978). That chapter contains also information on the history of cohort-sequential research. In the area of intelligence, Kuhlen (1963) and Schaie (1965, 1970) have written seminal papers on this topic.

For purposes of illustration, Figs.1-3 are offered. Figure 1 is taken form Baltes (1968) and shows why simple cross-sectional methodology is not only deficient but, if cohort effects exist, seriously misleading when it comes to the task of identifying developmental change. As simulated in Figure 1, a given cross-sectional gradient is always the result of two effect patterns, one related to age, the other to cohort. As a consequence, the cross-sectional age curve represented does not indicate the nature of coh[illegible]ecific age changes.

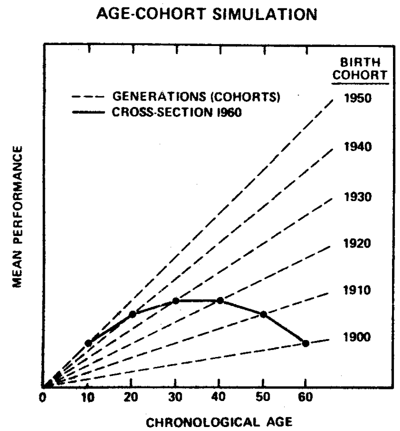

Fig.1. Illustration of age-cohort confounding in cross-sectional research on life-span development. Cross-sectional age differences are the combined results of age changes and cohort (generation) differences. (After Baltes, 1968)

Figure 2 presents for illustration concrete data on adult intellectual development taken from Schaie's (1970,1979) major cohort-sequential study. These data are based on an analysis reported in Nesselroade et al. (1972) involving 7-year longitudinal age changes (from 1956 to 1963) on four dimensions of psychometric intelligence for eight birth cohorts. Note the pervasiveness of cohort differences and the existence of differential change patterns for distinct dimensions of intelligence. Schaie's recent (1979) comprehensive report on 14-year age changes (1956-1970) for the same cohorts is suggestive of even more complexity in age-cohort relations and multidirectionality of psychometric intelligence than that summarized in Figure 2.

A critical task of gerontology, then, is the identification of intraindividual change (aging) in multiple cohorts. On a descriptive level, this can be accomplished by application of so-called sequential strategies (Schaie, 1965, 1977; Baltes, 1968; Schaie and Baltes, 1975). Figure 3 summarizes the basic design which has been labeled by Schaie as the General Developmental Model. It involves a matrix defined by three parameters; chronological age, cohort, and time of measurement. Mathematically, two of these parameters define the third. Observation of all cohorts at all age levels provides for all data points necessary to identify the four components of developmental variation specified above: within-cohort intraindividual change, within-cohort interindividual differences in intraindividual change, between-cohort differences in intraindividual change, and between-cohort interindividual differences in intraindividual change.

It is also shown in Figure 3, that there are two types of data collection strategies possible to accumulate data: *longitudinal sequences*, i.e., successions of longitudinal studies involving time-ordered sequences of birth cohorts. Longitudinal sequences

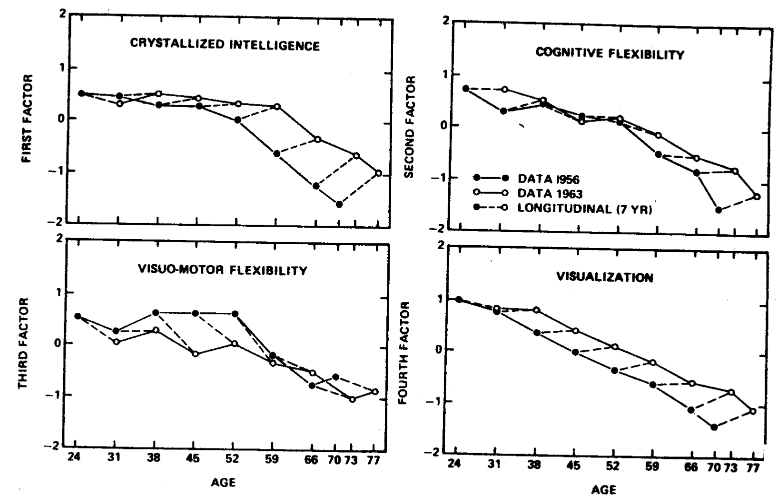

Fig.2. Results from Schaie's cohort-sequential research on adult intelligence. Longitudinal age changes for four ability dimensions involving eight birth cohorts each observed in 1956 and 1963 are shown. Cross-sectional gradients for 1956 and 1963 are also shown to permit comparison of cross-sectional with longitudinal outcomes. (After Nesselroade et al., 1972)

provide all points necessary for both intraindividual and interindividual analysis. In addition, *cross-sectional sequences* can be used. They consist of successive application of cross-sectional studies, which in the long run will yield also information on all cohorts at all ages. However, the information collected by cross-sectional sequences produces data at the interindividual (average, variability) level only; intraindividual change is not identifiable by cross-sectional sequences. Since cross-sectional sequences are based on independent observations across age, they are useful as control groups for repeated measurement (longitudinal) observations, for example, in the case of reactive testing (Baltes, 1968).

It is difficult to summarize the existing evidence on aging in psychometric intelligence which has been collected via application of cohort-sequential methodology. The existing evidence continues to be deficient for other design reasons, involving control groups and the need for more refined measurement. However, in our view, there are enough results to offer the following conclusions relevant for the present methodological discussion. In current cohorts: a) Chronological age per se accounts for a relatively modest amount of the variance observed in intellectual aging during late adulthood up to the early seventies. Differences between cohorts, up to age 70 (Schaie and Parham, 1977),

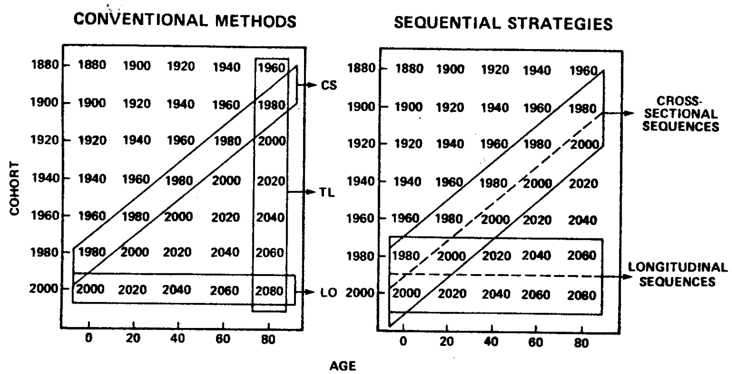

Fig.3. Schaie's general developmental model. Both conventional (cross-sectional, longitudinal, time-lag) and cohort-sequential strategies (longitudinal sequences, cross-sectional sequences) for data collection in descriptive research on aging are illustrated. The two types of sequential methods are distinguished on the basis of independent versus repeated measurement for levels of age. (After Baltes, 1968 and Schaie, 1965)

are of greater than or equal importance as are chronological age differences. Chronological age gains in prominence, however, as age reaches the late seventies. b) Interindividual differences in intellectual aging are large, suggesting differential (heterogeneous) rather than homogeneous patterns of aging. c) There is marked differential change also for distinct dimensions of intelligence (e.g., fluid versus crystallized), however, not only with age, but also with cohort.

In concert, such findings, based on cohort-sequential longitudinal research, present a picture requiring a conception of gerontological intelligence which has multidirectionality, plasticity, and differential aging as salient features (Baltes and Willis, 1979). This is in marked contrast to any position which would view fixedness of individual functioning and universal decline with age as the central theme of intelligence in late adulthood and old age (e.g., Horn and Donaldson, 1976; Horn, 1978). The task now at hand is less to argue about the magnitude of the observed effects, but to take the next methodological step which is to explore the conditions under which stability and change in older individuals are observed in measures of psychometric intelligence. In other words, the critical issue is not so much the argument about "how much," but more importantly, to paraphrase Anastasi (1958), about the "how" to organize and conceptualize the findings on differential aging.

Control Groups

Gerontological research on psychometric intelligence has also contributed to understanding the need for control groups when longitudinal research is conducted. Using Campbell and Stanley's (1963) classical framework for the evaluation of design validity, such control issues, or sources of error, have been reviewed in Baltes and Labouvie (1973), Baltes et al. (1977), and Schaie (1977) for the case of longitudinal research in life-span development and aging.

Control groups are necessary for at least three sets of possible sources of error, in order to control for them or assess their magnitude and direction in research on aging. A first set deals with changes in the parent population (e.g., birth cohort) itself, from which longitudinal samples are drawn. Biological mortality, if it is correlated with the dependent variable under study, is the classical example. A second set of source of error which require design control involves problems of changes in experimental samples due to initial selective sampling and selective drop-out. In general, the findings are that biological survivors, longitudinal participants, and longitudinal survivors score higher and show less aging decrement in psychometric intelligence than those who die, do not participate, or leave a longitudinal study before it is completed. A third set of control issues relates to questions of measurement validity and measurement equivalence. Examples are the problem of retest effects associated with reactive measures and the possibility of changes in the validities of tests when given to different ages and cohorts.

In the area of psychometric intelligence, each of these three sets of design problems has been shown to be relevant in empirical work (e.g., Baltes et al., 1971; Riegel and Riegel, 1972; Blum et al., 1973; Eisdorfer and Wilkie, 1973; Rudinger, 1976; Schaie, 1979). Strategies for design improvement have been proposed, and it is recognized that only longitudinal designs can provide for effective control. But it seems fair to conclude that there is not a single study which has attended simultaneously to the majority of these control issues in a prospective fashion. Thus, it is premature at this point to offer an overarching statement on the likely magnitude of the sources of error listed and on the specific implications for existing bodies of data (see, however, Botwinick, 1977). Moreover, because both age and cohort modulate the nature of such effects, it may be necessary to view the magnitude of the sources of design error as a dynamic phenomenon, both from an ontogenetic and historical perspective.

Adult and Gerontological Intelligence: Toward Explanation

Description and explanation are not separate enterprises. Because they are intrinsically related, the distinction between descriptive and explanatory work is strictly heuristic. Moreover, the form of description and explanation chosen is closely tied to one's metatheoretical position (Overton and Reese, 1973).

What is the current explanatory evidence on the aging of psychometric intelligence? First of all, we do know now that the explanatory task is not a simple one in the sense that the explanandum, the picture of descriptive changes in psychometric intelligence, is not a simple normative age function. Intelligence is not a unitary construct, but involves several dimensions of ability; there is little interindividual homogeneity, there is multidirectionality, and there is emerging evidence for intraindividual plasticity (both in terms of individual life courses and momentary variability). In other words, the descriptive pattern of intellectual aging is one of much complexity and little apparent parsimony.

Such a pluralistic outcome can be taken as evidence that research on psychometric intelligence is not one of the royal roads to understanding processes of aging. Or, if one were to take Comfort's (1964) evolutionary perspective, one could argue that there is little universality and parsimony in aging *per se*, because the evolutionary process has not led to a specific genetic program for that component of life. According to Comfort, this may be so because aging, as part of the postreproductive phase of life, is only tangentially related to species survival in the evolutionary sense. Such interpretations, while perhaps premature and discouraging, are reasonable alternatives which need consideration.

However, for the present methodological discourse on intellectual aging and without leaving the primary course of past investigation, there are a few observations which involve constructive implications for explanatory-causal research design. First of all, the key conclusion is that, except for perhaps advanced old age, there is not too much to be gained in explanatory research on psychometric intelligence by focusing on chronological age and age-associated mechanisms alone. For the most part, at least up to the early seventies, chronological age accounts for less variance than such subject variables as cohort, education, social-occupational status, and health (Green, 1969; Granick and Friedman, 1973; Rudinger, 1976; Schaie and Willis, 1979). Second, because of multidimensionality and multidirectionality, there is not much promise in research using an unitary construct of general intelligence. These observations also imply that, for much of late adulthood (but not for advanced old age), age-correlated normative biological changes in health are not sufficient, either to affect intellectual functioning at the level of group analysis (Eisdorfer and Wilkie, 1973; Eisdorfer, 1977), and/or to be not counteracted by the plasticity of the aging individual, its living environment, or other forms of behavioral and medical intervention.

A Multicausal and Interactive Model of Influences on Aging

One option for future explanatory work is to forcefully expand our conception of causation, to go beyond age-associated determinants and mechanisms, and to include factors which, while affecting intelligence, cannot be easily isolated if one follows a methodological paradigm which is primarily age-based. In this spirit, Baltes and his colleagues (Baltes and Willis, 1979; Baltes et al., 1978; Baltes, 1979) have formulated a multicausal and interactive model of influences on life-span development. This multicausal and interactive model of influences is represented in Figure 4. It is not advanced as a theory of development, but as a methodological paradigm, potentially useful in the search for causal relationships and determinants which make for intra-individual and differential development. It is argued that explicit recognition of the multiple influences represented will lead to a set of research enterprises which are structurally different from the research themes of the past.

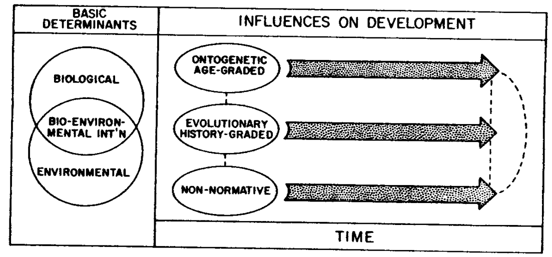

Fig.4 Toward a conceptual framework for identifying patterns of influences on aging. Three sets of influences (normative age-graded, normative history-graded, and non-normative critical life events) interact to produce aging at the individual and interindividual level. (After Baltes, 1979)

Specifically, Figure 4 identifies three sets of influences which, mediated through the developing individual, act and interact to produce development (aging) and developmental differences. The three sets of influences are normative age-graded influences, normative history-graded influences, and non-normative critical life events. Each of these influences can be conceptualized as having biological and environmental correlates and as reflecting interactive processes.

Normative age-graded influences are defined as encompassing those biological and environmental determinants which exhibit (in terms of onset and duration) a fairly high correlation with chronological age. They are normative, if their occurrence, timing, and duration is fairly similar for all individuals of a given set of aging cohorts. Examples of such normative age-graded influences are events and processes related to biological maturation, and to age-graded socialization including many aspects of education, the family life cycle, and of occupation.

Normative history-graded influences consist of those biological and environmental events which exhibit a fairly high correlation with historical change. Again, they are normative, if they apply to most members of a given set of aging cohorts in similar ways, although the effects do not need to be identical for different age-cohorts living at the same time. Examples of history-graded influences would be effect patterns associated with cohort differences, economic depressions, or the impact of wars or major epidemics on the life course of individuals.

Non-normative critical life events, finally, refer to determinants of development which do not occur in any normative age-graded or history-graded manner for most individuals; neither in terms of their presence or, if they are present, in terms of timing and patterning. Influences on life-span development associated with migration career changes, medical traumata, accidents, temporary unemployment, divorce, or the death of a significant other (widowhood), are examples for such non-normative critical life events. In a general context, Hultsch and Plemons (1979) have presented a stimulating discussion of the role of life events in understanding human development. As to cognitive aging, Eisdorfer (1977) has recently explored possible relationships between life events and cognitive functioning, using stress as the process by which such a linkage may be specified.

As we approach the explanatory study of aging in psychometric intelligence from the multicausal framework outlined in Figure 4, it may be possible to be more directed in our search by working from a *converging* framework of description and explanation (Baltes and Willis, 1979). Convergence between descriptive and explanatory efforts is possible, because the multicausal model outlined makes it possible to coordinate empirical findings on intellectual aging with their explanation. The findings of large interindividual differences and multidirectionality in psychometric intelligence, for example, appear less cumbersome, if the assumed determining influences exhibit a corresponding pattern of differential and multiple causation. The definition and operation of history-graded influences, but particularly of non-normative critical life events, is aimed directly at such a differential causal explanation. By definition, non-normative critical events, while important in regulating intellectual behavior at the individual level, do not occur in identical ways for groups of individuals. Therefore, they are not expected to produce homogeneous outcomes at the level of interindividual aggregation.

To use a concrete example: if it is correct that much of the evidence on psychometric intelligence suggests little normative age decline prior to the seventies for the majority of healthy older adults, the primary explanation of change occurring in some individuals might be found in non-normative life events, such as health traumata or other forms of personal crisis and opportunities. However, research on intellectual aging in advanced old age, assumed to exhibit age-graded normative decline, would appropriately be oriented towards causal schemes including a search for age-graded influences. Similarly, if one were to follow Botwinick's (1977) descriptive analysis if differential age change patterns, for example in verbal versus performance scores on the Wechsler, comparable decisions could be made about the likelihood of success in explanatory work. If age-graded, history-graded, and non-normative influence models and associated search strategies are contrasted as methodological paradigms, diverse models of explanation could be identified and tested to account for the differences in aging patterns observed for distinct classes of intellectual behavior.

In many respects, a focus on age-graded, history-graded, and non-normative critical life events poses new conceptual and methodological problems as to the logical status and further refinement of each of these influences. This is so, because neither of the terms denotes an exclusive category of antecedents or a specific process of behavior change. The three sets of influences denote search strategies rather than distinct theoretical constructs. Thus, as our knowledge about the importance of history-graded and non-normative influences develops, it will be necessary to specify the processes and mechanisms associated with their occurrence and transaction in similar ways as this has been true for the elaboration of age-associated factors. Illustrative examples for such elaboration are the use of stress and adaptation (Eisdorfer, 1977) as the process by which critical life events operate in controlling intellectual behavior, or the use of operant paradigms (Baer, 1973; Baltes and Barton, 1977) in specifying the nature of the transaction (or interaction) between aging individuals and age-graded environmental influences.

At this time, it is not clear whether the three sets of influences will lead to distinct process formulations. Alternatively, identical processes (e.g., various types of learning) may be used to account for the operation of each of them, though with perhaps different emphases and different levels of analysis. In any case, however, elevating history-graded and non-normative critical life events to a comparable level of explanatory power as age-associated factors will mandate new perspectives on research design. For example, one of the methods which appears to be ideally suited for the identification of the processes inherent in the multicausal and interactive model outlined is that of structural equation analysis (Goldberger and Duncan, 1973; James and Singh, 1978; see chapters by Joreskog and Ragosa in Nesselroade and Baltes, 1980). This method, developed primarily by researchers in econometrics and sociology, permits the formulation and evaluation of multivariate systems of variables in terms of directional and interactive causality. The study by Kohn and Schooler (1978) on the life-course relationship between occupational environment and intelligence summarized earlier is a persuasive application of the methodology in the topical area covered by the present chapter.

Process and Intervention Research Methodology

In an earlier section of this chapter, it was emphasized that information on intellectual behavior should include statements both about average performance (trait) and intraindividual range of performance (plasticity). Both types of information are not only important to separate components of capacity (competence) from that of performance in intellectual aging, but also to identify the conditions under which stability and change (incremental or decremental) in intellectual aging are obtained.

Process research of the experimental psychology type is rather standard in work on basic processes, such as learning, perception, attention, and cognition. In the area of psychometric intelligence, however, this type of explanatory work is relatively infrequent, although a number of articles have repeatedly called for it as a methodological paradigm (e.g., Tryon, 1935; Ferguson, 1954; Anastasi, 1970; Baltes and Labouvie, 1973; Buss, 1973). When does process research on intellectual aging attain particular relevance? There are two features of process research which such research aimed at the explanation of aging should exhibit. These features go beyond those usually associated with the design advantages of experimentaion *per se*.

First, for process research to be useful in the study of development (aging), it needs to take an observed developmental or aging phenomenon as the target for explanatory analysis. It is not sufficient to focus on any behavior change or any kind of interindividual variability as dependent variable. The behavior change under consideration must have meaning in the context provided by a given developmental theory or model.

The requirement of a developmental approach to defining the target for description and explanation has been expressed most forcefully in writings by Goulet (1973), Wohlwill (1973), Birren and Renner (1977), and Baltes et al. (1977). In the context of gerontology, the same perspective applies to the selection of explanatory mechanisms. Not any explanatory effort is likely to be useful. From the viewpoint of developmental theory, those explanatory mechanisms are good candidates which focus on antecedent processes having meaning in the context of a given theory of development or aging. The need for selecting a theoretically meaningful behavior-change process as a target is most apparent when a life-span approach to the study of aging is taken (Riley, 1979; Baltes, 1979). This is so because life-span developmental research on aging emphasizes aging as a life-long process. As one attempts to delineate a given behavior-change process, it is important to recognize the limitations of past process research which has largely centered on age functions and age-associated mechanisms (see, however, Riley, 1979). Thus, process research which deals with history-graded and non-normative influence and functions as a guiding framework will benefit if it is oriented explicitly towards a theory-based approach to the definition and explanation of process.

Second, it is important to recognize the dual role of intervention in such process research on aging (Baltes and Willis, 1977; Baltes and Danish, 1980). In any research paradigm involving experimentation to understand process, direct or indirect manipulation of antecedents (and the creation of treatment effects due to such manipulation) is the key rationale. The strategy of experimentation, therefore, is intrinsically linked to some form of intervention. However, interventive work can go beyond the causal control of variability as observed in a given phenomenon prior to the experiment. Intervention can include the planned magnification or reduction of intraindividual and interindividual variability. Such a planned magnification and/or reduction of a phenomenon is particularly important if the ecology, in which a given behavior-change process (the phenomenon) naturally occurs, does not present conditions for variability or certain segments of it, such as those necessary for optimal functioning.[3]

A number of researchers have argued that the naturalistic conditions of behavior (life) in the old person, in general (Baltes and Barton, 1977) as well as in the case of psychometric intelligence (Labouvie et al., 1974), are not supportive of efficient behavior in the sense of optimization. If the naturalistic conditions for life with regard to aging are indeed restricted in scope, it is imperative to emphasize process research which incorporates the second role of intervention work, that of planned magnification and/or reduction of intraindividual and interindividual variability. Information collected on the basis of such intervention paradigms will not only lead to a fuller understanding of the conditions for varying outcomes of life-span development including differential aging in intelligence. It will also provide for the type of information necessary to make recommendations for changes in social policy and health care, where knowledge about the conditions for dysfunctional and optimal aging is a central question (Baltes and Willis, 1979; Baltes and Danish, 1979).

As mentioned before, the recent years have seen a nascent interest in exploring the usefulness of intervention paradigms with the goal of understanding the conditions for varying forms of intellectual aging (e.g., Baltes and Schaie, 1976; Labouvie-Vief, 1977; Willis and Baltes, in press; for review). However, the bulk of past research on psychometric intelligence in old age is descriptive, youth-, and status quo-oriented. Therefore, not having much knowledge about the conditions for and range of intellectual plasticity is the result of past neglect of approriate methodology.

The concluding commentary offered on the need for interventive process research in the study of intellectual aging is another example of the critical role which established methodologies play as a field evolves. In the area of psychometric intelligence, the methodology appropriate for the study of intellectual aging will need to include some radical departures from the mainstream of past practice. Whether the same perspectives are applicable to other arenas of psychological research on old age, awaits further examination. However, it appears fruitful to venture such an hypothesis.

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[3]It is important to recognize that the identification of intervention conditions which produce variability in aging is not identical with the task of identifying the initial conditions responsible for a given phenomen. The search for the origins of aging in nature requires additional steps aimed at external validation (Baer, 1973; Baltes et al., 1977). The distinction between sufficient and necessary conditions is helpful to understand the logic of explanatory analysis in the context of developmental research, as is the concept of age- or developmental simulation (Baltes and Goulet, 1971).

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