BEYOND CALENDAR DEFINITION OF AGE, TIME AND COHORT: The General Developmental Model Revisited

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Invited Address Presented at the

91st Annual Convention of the

American Psychological Association

Annaheim, California, August 28, 1983

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Introduction

Almost two decades ago, at the 1964 meeting of this association, I first presented my thinking on the relationship between developmental data collected via the cross-sectional and longitudinal methods, by describing a general developmental model from which the two approaches could be derived as special cases together with a third approach which I named time-lag. That paper and the publications resulting therefrom (Schaie, 1965, 1967) received wide attention. In particular, it appeared that the more general sequential methods which I had suggested as extensions derivable from the general model offered the hope of unconfounding the age and cohort variance present in cross-sectional data as well as the confounded age and period (time-of-measurement) variance found in longitudinal studies.

What I had tried to make clear, however, from the very beginning was the fact that the three parameters defining the model (age, time, and cohort) could not be estimated simultaneous. Similar to the relationship in physics among the attributes of volume, pressure and temperature, it was concluded that given information on any two parameters, the third would be determined. Unconfounding the effects of any two paremeters therefore required the assumption that the third parameter was either zero or of trivial magnitude. Violation of this assumption would then result in sequential strategies permitting the comparison of any set of two effects confounded with the third.

Just as in the case of confounded physical parameters, there are many reasons why one would want to examine the relative contributions of any of the three possible sets of two parameters. While it is true that developmental psychologists may be most interested in an age by cohort matrix (cf. Schaie & Baltes, 1975), other social scientists may find age by time, or time by cohort matrices to be more informative.

In the original paper, I did offer some decision rules (modified in Schaie, 1970) which I thought would help the researcher who did not have a good base for determining which of the three parameters should be set to zero. These rules were purely intuitive and have been shown to be quite problematic. Their use would seem to require equal time and cohort intervals (Adam, 1977; Botwinick & Arenberg, 1976), and in any event is beset with the difficulty that a number of different permutations are not distinguishable using these rules (Adam, 1978; Buss, 1973). In my own work, I have therefore abandoned these rules in favor of making my assumptions explicit from the very begining (cf. Schaie & Hertzog, 1982).

The recent literature on the analysis of sequential data matrices would finesse the problem of possibly invalid parametric assumptions by promoting regression models which simultasneously estimate the effects of age, period and cohort under an additivity assumption which allows for no interaction among the factors (e.g. Buss, 1979/80; George, Siegler, & Okun, 1981; Horn & McArdle, 1980; Mason et al., 1973). These approaches represent a step forward in the modeling of average developmental functions by employing sophisticated applications of the general linear model. They are prone to errors of inference, nevertheless, whenever the assumption of additivity or other parametric assumptions needed to identify the model are violated (Glenn, 1976). For example, Glenn (1981) has shown how the additive approach can lead to cumulative errors when all effects from two or more of the three factors are monotonically ordered in a given study.

Given all of the above efforts I must now conclude therefore that a purely statistical solution has thus far defied us (also see Hertzog & Schaie, 1983; Schaie & Hertzog, 1982, in press). An alternative approach would therefore seem to be in order, and I would like to take this opportunity to reorient my own as well as your thinking in a manner which might suggest a possible way out of what seems to be a methodological impasse.

Much of our concern with methodologies designed to separate age, cohort and period effects has arisen from our pre-occupation with the role of age as the independent variable of prime interest to developmentalists. As a consequence, I will begin by argueing that one of the seminal contributions of life-span developmental psychology has been to question the primacy of chronological age as an explanatory variable, no matter how convenient or resilient this indicator might be. I will then examine in some detail how historical time and cohort effects can be conceptually separated from calendar time (cf. Schaie, in press). And, finally, I will present an approach to a possible reformulation of the general developmental model, given indicators freed from restrictions which we have thus far accepted as immutable.

Age as the Independent Variable of Central Concern

Chronological age has become recognized as having little explanatory power by itself, but is seen rather as an index that represents a variety of physiological and psychological influences that effect behavioral change over time. These influences in some instances are not yet known, in others they cannot be measured directly, or they occur in such complex interactive patterns as to prohibit parsimonious direct measurement (cf. Birren & Cunningham, in press). A variety of alternative indices, such as mental age, functional age or social age have been proposed from time to time. Although such alternatives may be conceptually more satisfying, they do have the disadvantage that their scale properties are ambiguous and their operational definition is dependent upon arbitrary decisions by individual investigators (cf. Schaie & Parr, 1981).

Because of the empty nature of age as an explanatory concept, Wohlwill (1973) proposed that chronological age ought no longer be used as the developmentalist's prime independent variable, but that it should be treated as part of the dependent variable. He implied that the prominence of age as a discrete independent variable in the popular ANOVA approach derived from the dominance of the cross-sectional method in developmental work. This approach becomes less attractive, however, once recognition is given to the fact that development is more often continuous than not and must be measured longitudinally to understand change within individuals. As part of the dependent variable of interest, age no longer serves as an empty explanation. Instead it now serves as a scaling factor, which indicates the number of time units over which a developmental process has occurred and thus permits us to understand the temporal progression of developmental change.

Age (or calendar time) as the dependent variable has other useful properties as well. For example, we can regress age upon measures of a behavior that is critical for survival or that has other social significance in order to determine at what chronological age maxima or minima are attained. Regressing such behaviors upon calendar time may similarly inform us about the elapsed time from the behaviors' onset at which optimal maxima occur or intervention-demanding minima are reached.

The retention of the status of age as an independent variable then seems motivated not so much by its scientific status as an explanatory construct, since most would agree that it has no such status, but rather for the pragmatic reason that we live in an age-graded society. But as our society begins to abandon many standards based upon age, even this consideration becomes slowly less tenable (also see Schaie, 1973b).

In any event, if age is to be retained as an independent variable there are strong arguments that the concept should be freed from calendar restraints and reconceptualized in behavioral or experiential terms. But there are at least two radically different directions which such reconceptualization could take. The first would continue to pursue the complexities of functional age, to substitute an age-related but substantively grounded index, which with sufficient effort might eventually attain scale properties approximating those of chronological age (see Heron & Chown, 1967; Nuttall, 1972; Schaie & Parr, 1981). The second would seek guidance from the life event literature (e.g. Brim & Ryff, 1980; Hultsch & Plemons, 1979) and develop indices which represent the scaling of life events that could provide more meaningful demarcations then the mere passing of calendar time (e.g. Featherman, in press b; Sparks, 1973; Tuma, Hannan, & Groenveld, 1979). Both of these approaches are faced with the fact that behavioral criteria or life events are strongly impacted by their historical context. Before proceeding along these lines, therefore, I would suggest that we set age aside for the moment and review the role of historical context for development.

The Role of Context in Life-span Development

One of the major contributions of the life-span psychology movement has been the shift from a search for purely "developmental" patterns of a normative nature to a concern with the context within which development occurs. Of particular importance here is that context is not simply confined to an ecology of situation, place and culture a la Bronfenbrenner (1977), but explicitly includes as a major parameter the historical time during which development occurs. It is not surprising that concern with historical period emerged largely from the study of adults. The need to establish behavioral competencies essential for survival dictates that children might reasonably be expected to possess at least some characteristics that ought to be constant across historical time. But few, if any, such behaviors seem important for development during much of adulthood, even though survival-relevant behaviors might once again merit concern for the study of advanced old age. For those variables where a behavioral asymptote is reached in young adulthood, therefore, age-related behavior change recedes in scientific interest. Indeed advances in the biological sciences that permit interventions leading to a rectangular scheme of development as proposed by Fries (1980) will in the future largely break the calendar age dependies for most behavioral variables. The developmental scientist interested in adulthood, therefor, is now faced with the need to delve into those matters which we have come to classify as cohort and period effects (see also Schaie, 1973a, 1977).

The concern with the context in which development occurs, however, arose originally in a manner not dissimilar to the efforts of early experimental psychologists who wished to control for individual differences because they were perceived to be major source of unwanted error variance. That is, our past view of historical time and generational effects has often been that of confounds that are best controlled and where possible explained away as experimental artifacts. Rosow (1978) was thus able to argue with some justification that the early work on sequential strategies (e.g. Baltes, 1968; Schaie, 1965) treated effects other than age as nuisances, or at best as sources of incidental information.

Whatever my own past sins may have been, they certainly do not extend to all developmentalists. Klaus Riegel throughout the latter portion of his work argued persuasively for a dialectic interplay of historical events with life stage and cohort effects (1972, 1975, 1976). Several of our sociological colleagues have addressed the interface of life stages and cohorts theoretically as well as substantively (e.g. Carlsson & Karlsson, 1970; Elder, 1974; Ryder, 1965). Sinott (1981) has discussed implications of the theory of relativity

for the study of development, which could provide metatheoretical support for our considerations. Even in my own more recent work, just as much attention was given to the estimation of period and cohort effects as to the study of chronological age, at times clearly de-emphasizing the role of the age variable (e.g. Schaie, 1979, 1983). Nevertheless it remains true that I have only recently begun to proceed beyond the identificantion of period and cohort effects as important components of individual difference variables, even though we have in the past tried to call attention to the potential importance of these effects for fields as diverse as mental health, adult education and the professional problems of engineers at mid-career (Schaie, 1978, 1981; Schaie & Willis, 1978).

My reluctance to proceed further may be explained by the fact that I have felt quite uncomfortable with the use of cohort and period as mere indices accounting for an otherwise unexplained proportion of variance in the dependent variable. When used in this manner, these construct are equally empty and subject to the same arguments as those raised earlier with respect to chronological age. I believe, however, that I can do better now and sketch for you a framework that will order historical context in terms which might have explanatory value for developmental psychologists. To do so effectively, it will be necessary to broaden the concepts of cohort and period. It will also be necessary to entertain methods for scaling the possible impact of historical events upon behavioral phenomena, and to contemplate ways in which individual differences in position on space-time templates for diverse attributes might be related to chronological age.

An Example of Historical Time and Cohort Effects in Psychological Data

My original concern about contextual effects began when I noted discrepancies between cross-sectional and longitudinal findings on age-related change in adult intelligence. Specifically, when I compared data from two cross-sectional samples drawn over identical age ranges from the same parent population seven years apart, I found that mean values on ability for the later sample exceeded those for the earlier sample with great regularity (Schaie & Strother, 1968). I also found that the overall mean for subjects at all ages differed positively over time. These findings suggested to me that there could either be the phenomenon of a unique period effect impacting all cohorts under investigation, or that there was a long-term trend involving successively higher performance asymptotes in young adulthood (see Schaie, 1983, for more detailed discussion). To resolve that question it became necessary to conduct an additional data collection which would permit the comparison of two or more cohorts followed over the same age range, a procedure which requires a minimum of three measurement points. This is precisely what we did, and the resulting data persuaded us that we were not faced with a period trend unique to the original seven-year time interval, but that we were rather faced with substantial cohort differences (Schaie & Labouvie-Vief, 1974).

But what could be the substantive meaning of either period or cohort effects in these data? To be quite frank, the time interval monitored was an artifact of the timing of research funding, and the cohort boundaries (and consequently the age ranges into which the sample was subdivided) were arbitrarily fixed to be equal to that time interval. If one is merely concerned with controlling cohort and period as confounds of the age variable then this approach is quite reasonable and it much simplifies numerical analyses. If substantive concerns, however, predominate it then follows that the use of equal time units may be appropriate only if it is possible to show that there are identifiable phenomena underlying the index variables of age and time which can actually be scaled in comparable units.

Serendipitously it appears that seven year intervals may actually not be bad divisors of the adult life span. The conventional use of 5 or 10 year intervals relates to our early imprinting of the decimal system; it has no psychological meaning. In my own adult life, I have found that changes of major significance, whether in professional or personal matters, have often taken longer than 5 but less than 10 years. Note further, that the full range over which adults can be found with sufficicient frequency to be readily researchable can be conveniently divided into ten segments of seven years each, six of which currently occur during the conventional work life, and four subsequent to the typical retirement age. Perhaps you will argue that such considerations are even weaker than the plea for computational convenience, and you would be right. Fortunately, however, carefully collected data sets will eventually force our attention to the absurdity of arbitrary classification schemes.

Insert Figure 1 about here

I would like to illustrate this point by calling attention to Figure 1, which presents data on the Spatial Orientation variable from the Primary Mental Abilities Test (Thurstone & Thurstone, 1949) for a data set in which all 162 participants were examined three times in seven year intrervals, their age at test being shown on the abscissa. The ordinate gives mean performance in T score points (Mean = 50, S.D. = 10, scaled upon a larger adult sample at first test). This figure shows the intra-individual change observed for seven cohorts followed over a fourteen-year period. The youngest were followed from mean age 25 to mean age 39, the oldest from mean age 67 to mean age 81. Many of you have seen this figure before, but what I would like you to pay attention to today is the following: If we study the separation between adjacent cohorts it becomes apparent imediately that the specified cohort boundaries are quite arbitrary. The three oldest cohorts seem quite distinct in level and slope from the next two, and those again are clearly distinct from the youngest two. Instead of the forced seven cohorts in this data set, there appear to be three "natural" cohort groupings.

The gap between the three "natural" sets seem to be curiously close in temporal contiguity to World Wars I and II. That is, the oldest group was educated prior to World War I, the second between the two wars, and the youngest group was educated either during or shortly after World War II. Even such interpretations represents the rankest *ad hoc* approach to the interpretation of cohort effects, and if done at all would be more appropriate for those with sociological or historical background (e.g. Cain, 1967; Hareven, 1982). I shall now attempt to consider from the behavioral point of view how we might go about to take a more scientifically acceptable stance to the definiton of cohort and period effects in the study of human development.

Cohort as a Selection Variable

Developmental psychologists have thus far utilized the cohort concept primarily as a way of organizing groups of individuals by their birth year. I have recently tried to broaden that use by defining cohort as " . . . the total population of individuals entering the specified environment at the same point in time" (Schaie & Hertzog, 1982, p. 92). It should be explicitly noted that the point of common entry need not necessarily be birth and that there are many other ways in which individuals can enter a specified environment under study (see Figure 2)*.

Insert Figure 2 about here

Baltes and his associates (1979) have classified these influences into three basic types: Age-graded, history-graded and non-normative. Samples selected in terms of the first of these influences would be almost (but not entirely) as homogenous by age as would result from selection by birth year alone. Examples of age-graded cohort definers (in declining order of presumed correlation with chronological age) would be entry into the public school system, menarche, birth of first child, becoming a grandparent, retirement and death. Note that these cohort definers include biologically as well as societally programmed life events. What they have in common is the attribute of being essentially *normative* in nature, and that even those influences that are programmed by societal norms, are still constrained by relevant biological characteristics that are ordered by age.

Other possible cohort definers may be quite randomly distributed in the population with respect to age, at least over the broad range of middle adulthood. Such definers are likely to be history-graded influences which form cohorts defined by events such as the staffing of a new college or corporation, the induction of conscripts in a general mobilization, those entering the ranks of the unemployed during a recession or depression, or during periods of rapid technological change, those who enter a given class of a technical or proprietary school (cf. also Hannan & Freeman, 1977).

Cohorts can also be formed by the common experience of certain non-normative events. Non-normative events, for this purpose, may be defined as those favorable events that are not essential for the adequate development or survival of all (or even most) persons, and the unfavorable events which may affect some persons' development but that may be avoidable for many individuals. The temporally close experience of such non-normative events, then, can result in the formation of definable cohort groupings. Obviously these cohort definers are generally uncorrelated or at most moderately correlated with calendar age. Examples would include, divorce, experience of an infectious disease, onset of a disabling condition, membership in a particular social group, purchase of a home in a particular neighborhood, and so on.

It is important to note that equal-interval boundaries are possible only for some of the above-described cohort groupings, and that it is only the biologically determined age-graded influences which permit assignment of all individuals to cohorts representing levels of a given influence. This restriction might persuade some investigators to be rather cautious in trying out my proposed broadening of the cohort concept or restrict such broadening to universally assignable attributes. Let me stress, however, that assignment to cohorts defined by influences holding only for limited sub-populations may actually yield more powerful predictions in individual cases than is possible from knowledge of their standing on universally defined characteristics.

Periods as Discrete Events

We have noted that it is possible to generate cohort definitions which can be uncoupled from chronlogical age. In a similar manner, I would now propose that period can be uncoupled from its identity with specific calendar dates. Indeed, if the status of the time-of-measurement construct is to be converted from an index variable to an explanatory concept, we would note that what is of interest to us is not a particular calendar date but rather the historical event or events for which that date is an indicator. To my knowledge, this notion was first introduced by Sorokin and Merton as long ago as 1937, but it has certainly had little impact thus far, particularly in the study of development. As for our analyses of alternate cohort definers we need some organizational principles. Unfortunately the ones proposed for cohorts will not work because period effects are history-graded by definition!

To find an alternate classification scheme we might begin to note the range of impact of history-graded events. Some do have universal impact, such as major wars, or the introduction of technological changes which achieve virtually instantaneous and universal acceptance. Other events are far more parochial in nature and affect only certain localities or specific sub-sets of the general population. They may be cohort-specific under our new and broadened definition.

Of further concern is the fact that all events, whether general or specific, may impact different localities or even different individuals at different points in time.

Our earlier definition of time-of measurement, as " . . . the point in time at which the response of interest is recorded (Schaie & Hertzog, 1982, p. 92)." thus no longer suffices. What is now needed is a manner of designating the calendar date at which a particular historical event has had the opportunity to impact a specified proportion of our target population. For the most intensive study of individual development, moreover, it would be necessary to assign to each individual a period index for each developmentally influential event under study which would designate when such influence could have impacted the target person. As a corollary we would, of course, also wish to designate an indicator reflecting the temporal cessation of the event's impact.

Critical to the utilization of a broadened period concept is the identification of historical events which may be presumed to have developmental impact during the life course of subjects under study and scaling the temporal position of greatest impact (or duration of impact) of such events. Two separate problems are implicit in such an approach. The first is concerned in identifying what kind of events are likely to have impact upon development, and here we can lean upon substantial work of developmentalists interested in the contextual aspects of life events (e.g. Brim & Ryff, 1980; Hultsch & Plemons, 1979; Lerner, in press). The second issue, that of identifying the temporal position of such events, has received some attention in the sociological literature, particularly in the context of treating individual development as a population process (e.g. Allison, 1982; Featherman, in press a & b; Tuma, 1982; Tuma, Hannan, & Groenveld, 1979). My own approach differs somewhat, in that I do not wish events to be aggregated in a manner that could result in an alternative for chronological age akin to some of the earlier proposals for some type of social age index (c.f. Neugarten & Datan, 1973). What I want to do explicitly is to define the new indicators required for my redefinition of the period (time-of-measurement) construct.

How do We Measure Historical Event Time?

To begin with it will be necessary to conduct a critical analysis of modern history texts, while minding the findings of the life event literature, in order to create a taxonomy of development-relevant historical events. Professional raters can then be used to classify these events vis-a-vis their relevance to specific behavioral domains. Ratings of similarity can then be used to cluster events and reduce the large number that could be studied to more manaegable and representative proportions. The process to be envisaged is not unlike that which led eventually, from the original taxonomy of behavior relevant trait names conducted by Alport and Odbert in 1936, to more modern strategies for the definition and measurement of the trait domain (e.g. Cattell, 1957; Nesselroade & Bartsch, 1979).

Having selected a workable number of discrete events and having identified their dimensions, we must then proceed with some further search of the historical literature to obtain temporal anchor points upon which to base our quantification. Specifically, we would want to note the calendar date of first possible impact of a given event, as well as the date at which such impact had become universal for the target population under study. A prudent approach might be to define relatively conservative boundaries, such as the year when 10 per cent of the population had adopted a technological invention (e.g. the automobile, the telephone or television) or accepted a changed custom or attitude (e.g. integration of public schools, jogging, or mini-dresses), and that year when 90 per cent of the population had become impacted by the change event. Event impact, however, is not necessarily uni-directional and can have forms other than linear progression from its inception to its universal impact. Thus we might also consider a criterion of an event having ceased to have impact when less than 10 per cent of the target population remains affected. I have sketched rough schemata for examples of events showing different patterns of impact in Figure 3.

Insert Figure 3 about here

No historical event impacts behavior in isolation, and the relative impact value of events occurring during the same or overlapping temporal intervals must be assessed. In those instances where information is available on individual experience of the historical events as occurring concurrently with behavioral measurements, it might well be possible to assess the relative importance of different events directly by means of appropriate regression analyses. In the absence of the requisite data base, it might still be possible to rely once again upon expert judgments to obtain the necessary parameters. Once this is done we would then proceed to re-scale calendar time in terms of historical event impact density.

Given a schema of multi-dimensional event classifications, we would now be able to substitute for the conceptually empty calendar period, alternative time frames which have greater explanatory power. For example, there might be one event-density based calendar for technological change, another for health-relevant interventions, a third for sexual mores, a fourth for the rate of information acquisition, and yet another for events enhancing self-awareness.

Our bradened approach to the concept of time-of-measurement (period) as a set of events marking different dimensions of events occurring in historical time requires attention to a number of event

characteristics, which have received some attention in the sociological literature (cf. Allison, 1982; Featherman, in press; Zerubabel, 1981) but which heretofore have been largely ignored by psychologists. I have summarized these event attributes in Figure 4.

Insert Figure 4 about here

Attention to these event attributes, and their inclusion in the operations I have suggested for the re-scaling of calendar time, will ensure that the new indicators of time delineating a developmental sequence will have psychological meaning. It might be argued further that moving from our previous enslavement to a purely physcial time dimension to a more existentially meaningful time-frame might succeed in bridging some of the current ideological gaps between those of us who believe in a hard-nosed experimental approach and those who would take a more humanistic stance towards life-span development (cf. Neugarten & Datan, 1973; Schaie, 1973b; Sparks, 1973). To avoid possible misunderstandings, however, I would like to stress that it is not my intent to substitute a purely subjective calendar for real time. What I am suggesting is that historical time be redefined quite objectively in terms of event density. That is, time employed as the independent variable is to be scaled such that priods of time which are filled with behavior-relevant events will count more than other periods which are relatively devoid of such events. It is my contention then that the new event time units would be likely to correspond much more closely to changes in the variables of interest to developmentalists than do age and calendar time.

Implications for a Redefinition of the General Developmental Model

What I have done up to this point, is to redefine our basic terms, and to take some initial steps towards operationalizing these terms in their new form. It now remains to consider possible implications for a redefinition of the General Developmental Model and to examine how our redefinition would affect approaches to the estimation of age, cohort and period effects. I will begin this discussion by showing how our reconceptualization will help in more clearly distinguishing between cohort and period effects.

Distinguishing Features of Cohort and Period. Our broadening of the two concepts calls attention to a rather important difference between the two constructs. This difference refers to the fact that cohort as a selection variable clearly must be and can only be an inter-individual difference variable. Our broadened definition of cohort allows one simultaneously to be a member of two or more temporally distinct cohort classifications. For example, one can at the same time be a member of the initial (oldest) group of residents in a sub-division and be a member of the most recent (experientially youngest) group of initiates in a social club. Nevertheless, there simply is no way in which one can belong to two cohort levels on the same selection variable.

By contrast, period effects, whether calendar or event time, whether or short or long, must be in the nature of intra-individual change; they imply a duration, a beginning and an end point, that do not occur simultaneously in time. What is possible and quite likely, however, is that two different individuals co-existing during the same calendar time period, will experience the same events on a different time scale, or experience different events at the same point in time. This is precisely why we introduced the concept of event time.

Implications for the Estimation of Pure Age Effects. The salient distinction between cohort and period made above sheds further light on the inter-relation between cross-sectional and longitudinal data. It clarifies the fact that chronological age has the status of an inter-individual difference variable in cross-sectional data, but that of an intra-individual change variable in longitudinal data. What is held in common by the two age indicators, therefore, must be other than cohort membership (now defined as a multiple selection variable) or experience of historical events (now considered as event time density). What then is left for the concept of age *per se*? This is the point at which I find myself returning to a rather restricted maturational view. Pure age effects, when exctricated from cohort and period confounds should thus reflect age-graded phenomena which are strictly species-specific biological and/or ethological in nature. All other variance will be accounted for by group membership (multiply defined) and the experience of history-graded events. Moreover, I believe I am essentially in agreement with Featherman (in press a & b), when he states that such pure aging effects are essentially population processes, not phenomena which can meaningfully be assessed at the level of the individual.

Implications for Sequential Data Collections. When I broadened the cohort construct, I allowed for cohort groupings, membership in which is not necessarily a function of common chronological age boundaries, and when I redefined period effects as event time, I broke the dependency between period effects and calendar time. In the extreme instance, then where either cohort and/or period is orthogonal to chronological age, we have essentially succeeded in breaking the inevitability of the indeterminancies contained within the general developmental model as originally stated (1965). In other instances, the indeterminancy is partially broken, provided we shift from an additive to a multiplicative model. Given our reconceptualization of cohort and period it is now possible to imagine, at least for limited life stages, research designs which permit the independent specification of age, cohort and period effects.

When we specified the dimensions of the general developmental model to be constrained by calendar time, it soon became apparent that

what I termed the cohort-sequential method (i.e. analysis of age by cohort data matrices) was the approach of choice (cf. Baltes, 1968; Buss, 1973; Schaie & Baltes, 1975). Freeing our constructs from the tyranny of the calendar, however, raises serious questions whether this conclusion can remain valid. If pure aging is viewed as a species-specific population process, then as students of individual development, we are no longer concerned with differentating intra-individual change and inter-individual differences. Such differentiation then becomes primarily a nature-nurture issue, and I might return to my earlier suggestion that the cohort-sequential method may have useful applications in behavior genetics (Schaie, 1975).

For us, however, the interest now turns to the differentiation of inter-individual differences in intra-individual change from inter-individual differences in level, and this can best be accomplished by studying research-time-wise more economical cohort by time response matrices, what we have called the cross-sequential method. By defining cohort as a selection variable and period as an event density index, we have essentially removed calendar age as a confound for cohort or period. We still have the option, the exercise of which seems sensible to me, to treat calendar age as part of the dependent variable, and/or to use nonchronological indices of age as covariates in our analysis, independent of calendar time.

For the developmental social psychologist, who views development as a population process (cf. Featherman, in press, a & b), the time-sequential method becomes of interest, since it permits us to differentiate age/cohort status from period effects. Once period effects are redefined as event-density indices, the confound with cohort is removed. Indeed, age now has the primary function of classifying subjects by the *duration* from birth to the points in calendar time where the event-density is being measured, and thus simply becomes another possible (cohort) selection variable. The principal conceptual distinction between the cross-sequential and time-sequential method under the new definitions then lies in the fact that period effects will be inter-individual differences in intra-individual change in the former, but time-ordered inter-individual differences in the latter; repeated measurements are thus required in the cross-sequential design, while successive independent samples would characterize the time-sequential data matrix.

Once the indeterminancy of the relations between age, time and cohort is broken, it becomes reasonable again to utilize ANOVA approaches to the analysis of directly observed variables, particularly in those instances where we wish to continue using chronological age as a selection variable or where we are concerned with non-continous categorical cohort levels (see Schaie, 1977; Schaie & Hertzog, 1982)[3]. When primary concern, however, is in the study of latent constructs, or when whole variable systems are to be decomposed into their sources of developmental variance, then it would seem more appropriate to employ methods of linear structural analysis (cf. Hertzog & Schaie, 1983; Horn & McArdle, 1980; Schaie & Hertzog, 1982, in press).

Structural Modeling Applied to the General Developmental Model. Applications of structural modeling to developmental data matrices have thus far taken the primary stance of explaining individual difference variance at Time 2 as a function of individual difference variance at Time 1 (see Jöreskog, 1979; Schaie & Hertzog, in press). There is no reason, however, why we could not utilize the LISREL paradigm (Jöreskog & Sörbom, 1981) to regress a set of observations which measures a system of latent constructs upon another set of empirical measures selected so as to define calendar-free concepts of cohort and period (see our earlier discussion of definers for both cohort and period). We can, if we wish, include calendar age on the *x* side as a directly observed independent variable, or we can incorporate calendar age on the *y* side of the equation as a directly observed dependent variable to be regressed upon the cohort and/or period definers. If we do the former, we may express any non-orthogonal hypotheses about the relation between calendar age, cohort and period, by appropriate fixing of the factor inter-correlation matrices, as well as specifying correlated error between calendar age and the other dimension. If calendar age is treated as a dependent variable, similar specifications are possible of its hypothesized relation with the dependent variable system.

It should be noted, however, that the modeling proposed here would not be meaningful if it were done simply by regressing the Time 2 observations upon the explanatory constructs. The individual differences that we wish to decompose involve the measures of intra-individual change, and that means, with all its attending problems, the direct analysis of change scores as our dependent variable measures (cf. Nunnally, 1982; Rogosa, Brandt, & Zimowski, 1982; Schaie & Hertzog, in press).

Summary and Conclusions

The objective of my original work on the general developmental model was to contribute toward the development of methodologies for a more valid description of developmental phenomena occurring over time. Applying some of these methods to my own empirical work I have come to realize that chronological age as such has little explanatory power and turns out to be a rather empty indicator of individual status on the behavioral phenomena I have been interested in. While dealing with this problem, my attention began to focus on the contextual dimensions of cohort and period (time-of-measurement), at first seeing them as unwanted confounds for our understanding of age changes, to be con- trolled as threats to the internal validity of our studies. Over the years, it has become evident, however, that these constructs, rather than being merely inconvenient confounds, may be of great and primary interest to the developmental scientist.

Although there has been considerable preoccupation with the methods for separating cohort and period from chronological age, there have thus far been few attempts to assign specific meaning to these concepts. In this presentation, I have argued that cohort and period must be freed from their dependence upon calendar time. I have redefined cohort as a selection variable and suggested some organizing principles as to the various ways in which cohorts can be composed. Similarly, I redefined period as event time, examined the attributes of events of concern to us, and suggested an approach towards the scaling of historical time which might lead to the development of event density indices. I then proceeded to show how the indeterminancies contained in the general developmental model can be resolved, if one or more of the component constructs can be redefined in the manner suggested here.

With respect to the age variable, moreover, I suggested that we ought to more serioulsy consider the recommendation that it be treated as the dependent rather than as the independent variable. Since pure aging effects can best be conceptualized, moreover, as a population process rather than as an individual differences variable, I suggested that the sequential data matrix of choice might shift from the cohort-sequential to the cross-sequential design. The latter would permit differentiating effects due to individual differences in individual change, that should be of primary interest to developmentalists. Other consequences for sequential analyses were also considered, and the application of the LISREL paradigm to the study of age, time and cohort was briefly considered.

Much more needs to be said about the specific ways in which the proposed reconceptualizations will affect interpretation and design of the conventional developmental data collections. Indeed, I am well aware of the fact that what I have presented to you today requires further explication and operationalization. For that to happen, however, and within the time available to me today, it seemed to me first necessary to attempt to break what may have become a methodological impasse. Instead of merely creating chronicles of behavior change as we move through time, it is now up to us to discover the specific influences that determine these changes. If this paper will provide a further stimulus in what I perceive to be a new ground swell in moving from description to explanation in the developmental sciences, I will be well satisfied.

Footnotes

[1]An earlier version of parts of this paper was presented at the 1982 West Virginia Life-Span Psychology Conference (see Schaie, in press).

[2]For alternate but related conceptualizations of these issues see Nesselroade (1981), Nydegger (1981) and Rosow (1978).

[3]Recent refinements for the analysis of sequential data methods are described in Schaie and Hertzog (1982).

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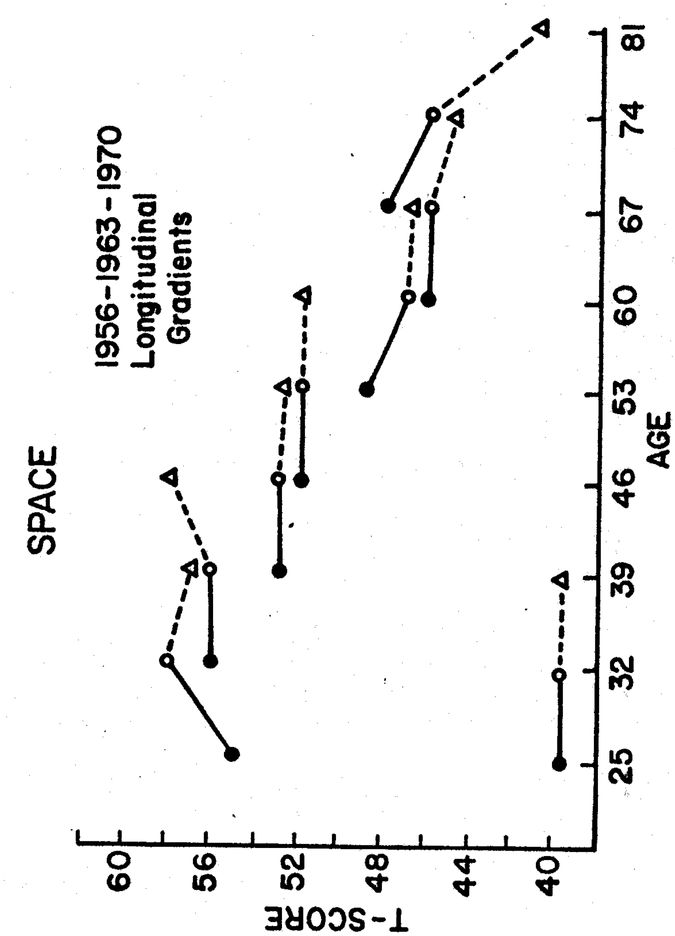

Figure I. Longitudinal age gradients for Space.

AGE-GRADED

BIOLOGICAL:

Menarche
Menopause
Birth of First Child
Becoming a Grandparent
Death

SOCIETAL:

Entry into School System
Voluntary Enlistment in Armed Forces
First Marriage
Retirement

HISTORY-GRADED

Initial Staff of New College or Corporation
"Class" Entering Ranks of Unemployed
Class of Technical or Proprietary School
Conscripts Called up in a General Mobilization

NON-NORMATIVE

Divorce
Infectious Disease
Accidental Onset of Disabling Condition
Membership in Social Group
Purchase of Home in New Neighborhood

Figure 2. Alternative Cohort Definers: Some Examples

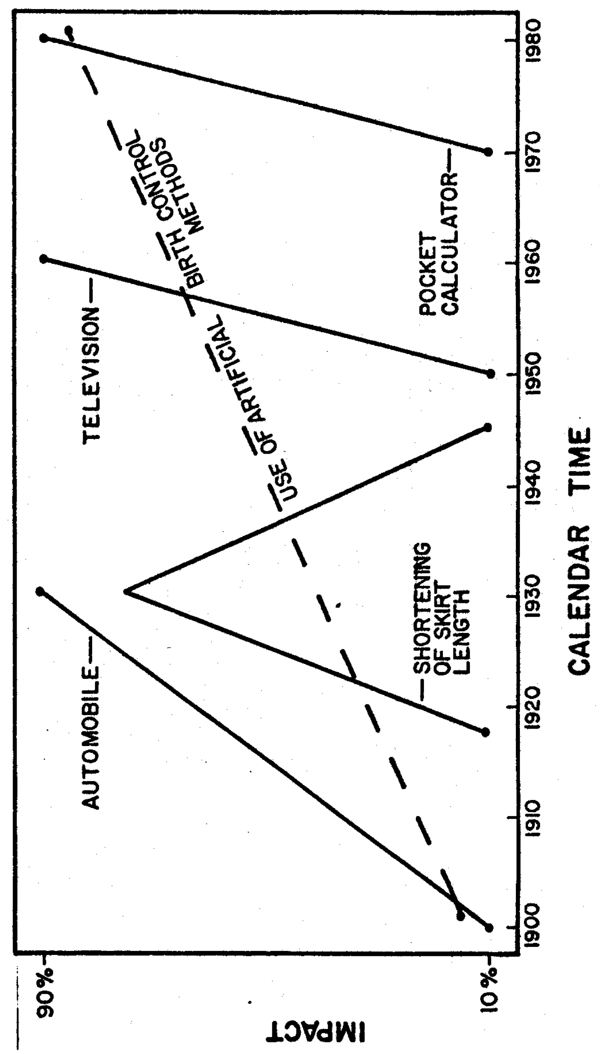

FIGURE 3. PERIOD AS EVENT TIME

TYPE OF EVENT

- Technological
- Attitudinal
- Personal Habits
- Knowledge Diffusing

IMPACT OF EVENT

- Initial Occurrence (Impact on 10% of Target Population)
- Universal Recognition (Impact on 90% of Target Population)
- Dissipation (Impact on less than 10% of Target Population

DIRECTION OF THE IMPACT

- Linear
- Recursive

EVENT DENSITY

- Population Effects
- Individual Effects

PERCEPTION OF EVENT

- Objectively Defined by Professional Judges
- Subjectively Perceived by Individual

Figure 4. Characteristics of Events Marking Historical Time