Alternate Models for Age Changes in Cognitive Behavior[1]

K. Warner Schaie

West Virginia University

Abstract

Simple maturational decrement models rarely fit data covering extensive portions of the adult life span. Alternate models will be considered which include maturational increment and decrement, improvement and decrement in the species, as well as improvement and decrease in environmental opportunities. It will be shown that discrepancies between findings of longitudinal and cross-sectional studies can be resolved by postulating interactional models. These models include improvement in the species, increase in environmental opportunity and mild maturational decrement. Implications for the interpretation of findings from developmental studies discussed in the symposium and for the design of prospective studies will be considered.

[1] Paper presented at a symposium on cognitive functioning of elderly people at the Atlantic City meeting of the Eastern Psychological Association, April, 1965. Preparation of this paper was supported in part by a Public Health Service research grant # HD 00367-02 from the National Institute of Child Health and Human Development.

The previous speakers in this symposium have admirably described recent researches in the areas of age changes in perception and learning and they have forcefully pointed to some of the insights which are rapidly leading us away from the simple-minded descriptive attempts of an earlier area in the psychology of aging.

Both of the speakers, however, have addressed themselves primarily to the question of how do older individuals differ from their younger peers in our own day and age. Such an attempt is quite worthwhile and necessary in the standardization of measurement instruments and in describing the very real differences among organisms of varying length of life experience at a given point of time. Nevertheless, unless some very potent assumptions are made, it does beg the issue and fails to produce relevant experiments on the question of how the behavior of an organism changes over age.

I make these charges in great sorrow and sympathy as I find myself increasingly puzzled about the results of my own and other's studies of age differences. I will try to be explicit in clarifying the basis of my concerns and trace their implications for the interpretation of the data reported here by my colleagues.

I have previously documented why the traditional cross-sectional and longitudinal methods are inadequate methodologies for the study of aging effects (Schaie, 1965) and together with Strother have shown the application of more fruitful methodologies in the areas of intelligence and rigidity-flexibility (Schaie and Strother, 1964a; 1964b; 1964c). At this time I would like to recall for you the most important characteristics of the general model required for the explanation of aging phenomena. I must beg the forbearance of those of you who have heard me expound these matters before. They are necessary prologema, however, if I am to be understood when I will show why I think Comalli (1965) is correct when he suspects the beautiful fit of his perceptual data to Werner's model of development and when I shall speculate about the most plausible meaning of the interesting interaction effects presented by Canestrari (1965).

Let us begin by clearly distinguishing between the concepts of age changes and age differences. Inspection of Figure 1 will help us in this endeavor. This figure shows a set of six independently drawn samples three of which have a common age, three of which are tested at the same point in time and three of which have been drawn from the same cohort; i.e. whose date of birth is identical. If we compare the performance of samples 1, 2 and 3 we are concerned with age differences; i.e. discrepancies may be due to the difference in age for samples measured at the same point in time. But note that an equally parsimonious interpretation would attribute such discrepancies to the differences in previous life experience of the three different cohorts represented by these samples. If, on the other hand, comparison is made between scores for samples 3, 5 and 6, we are concerned with age changes. Here the performance of the same cohort is measured at three different points in time. Discrepancies may therefore represent true age changes, or they may represent environmental treatment effects which are quite independent of the age of the organism under investigation. Lest it be thought that there is no way to separate the effects of cohort and time differences from that of aging, we shall now consider a further set of differences which we have called time lag. If we compare samples 1, 5 and 6, we note that we have differences which are independent of the organisms' age, but which can be attributed either to differences among generations or differences in environmental treatment effects or both. Clearly then any definitive study of age changes or differences must recognize all three components of developmental change or, as in the past, we shall continue to confuse age changes with age differences and both with time-lag.

It follows from this discussion that studies of age differences can bear upon the topic of age changes only in the special case where there are no differences among generations and where there are no effects due to environmental impact. Findings of significant age differences therefore have no necessary relation to maturational effects, nor does the absence of age differences guarantee that no maturational changes occur.

A further complication must now be introduced by noting that differences in the direction of change for the confounded developmental components will lead to a suppression or exaggeration of actual age differences or changes. To cite an example, let us suppose that perceptual speed declines at the rate of one-half sigma per five year interval. Let us suppose further that the average level of perceptual speed for successive five-year cohorts declines by one-half sigma, perhaps due to systematic changes in early experience or some unexplained genetic decrement. If these suppositions were true, a cross-sectional study would find no age differences whatsoever. As another example, let us suppose that there is no maturational age decrement but that there is a systematic improvement in the species. In the latter case successive cohorts would do better than earlier ones, and cross-sectional studies would show steep age decrement curves, very much like those reported for many intelligence tests.

We are now ready to apply our notions to the identification of alternate developmental models which may account for the observations reported by my colleagues today. Let me first of all address myself to Dr. Comalli's data. This will force me to specify possible alternatives which do not only apply to Werner's notions but are relevant directly also to my own ventures into aging theory (Schaie, 1962).

We face relatively little difficulty in answering the question whether maturational change is contained in the age differences noted during childhood and adolescence. Our own children provide us with longitudinal evidence of such change. Whether this portion of the curve, however, is a straight line or a positive asymptotic gradient is still in doubt. Also, it should be remembered, that even if we assume positive maturational changes, we must still consider that such changes will be over-estimated by cross-sectional data if there are positive cohort differences and/or negative environmental experience effects. Similarly maturational growth will be underestimated in the event of cohort decrements or the effects of positive environmental influences.

For the adult and old age portions of the developmental gradient matters are much more complicated. It should be remembered that while we can accept the fact of psychological maturational growth during childhood, similar evidence of maturational decline on psychological variables by means of longitudinal study remains to be demonstrated. As a consequence we must at least entertain also models which would account for age differences in the absence of maturational age changes.

I have shown elsewhere, that it is possible to differentiate as many as 729 models to account for developmental change if one considers the direction and slope as well as the three components involved in developmental change gradients (Schaie & Strother, 1964c). Of the many possible models, I would like to consider here three which to me seem plausible ones. They are models which would first of all fit the data presented to us by Dr. Comalli, but which would further predict that his data could not be replicated in a longitudinal study.

The first of these models I shall call the "improvement of the species" model. It holds that the form of the maturational gradient underlying our data is positive asymptotic; i.e. systematic increment during childhood, slowing down during early adulthood with no further maturational change after maturity. It further holds that the cohort gradient shall also be positive asymptotic; i.e. successive generations show improved performance for some unspecified genetic or prior experience reason, but the improvement has reached a plateau for recent generations. The effect of the environment is furthermore assumed to be constant or positive asymptotic also. When we combine these components we can readily see that they will provide a cross-sectional age gradient which shows steady increment during childhood, a plateau in midlife and accelerating decrement in old age. The same model, however, when applied to longitudinal data will predict again steady increment during childhood, but slight improvement in midlife and no decrement thereafter.

The second alternative may be called the "environmental compensation" model. It specifies a concave maturational gradient much as that depicted by Dr. Comalli's data, with increment in youth and decrement in old age. In addition, however, this alternative also calls for a positive environmental experience gradient; i.e. the effect of environmental experience increases systematically due to a progressively more favorable environment. The effects of cohort differences in this model are assumed to be neutral or positive asymptotic. If this model were correct then our prediction of longitudinal age changes would result in a gradient with steep increment in childhood, but no decrement thereafter since maturational changes would be systematically compensated for by a favorable environment.

Thirdly, let me propose a more extreme alternative which we might label the "Great Society" model. This model specifies a positive asymptotic maturational gradient; i.e. increment during childhood and a plateau thereafter. It specifies a positive asymptotic cohort gradient; i.e. successively smaller increments in performance for successive generations. Lastly this model specifies increasingly favorable environmental impact. The reason for calling this alternative the "Great Society" model should be readily apparent. It implies (a) that maturity is an irreversible condition of the organism, (b) that the rapid development of our people is reaching the plateau of a mature society and (c) that any further advances will now be a function of continually enriching the environment for us all. Note that the cross-sectional study of groups of different age at this time in our history will still conform to Dr. Comalli's gradients. Their longitudinal replication, however, would result in a gradient which would be steep during childhood, which would level off during adulthood, but which would show continued growth until the demise of the organism.

Obviously, it is still possible that a straightforward decrement model might hold equally well. The information we have from longitudinal studies such as those of Owens (1953) and Bayley and Oden (1955) and the more recent sequential studies of Schaie and Strother (1964a; 1964b) let it appear though that my proposed alternatives are the more reasonable ones.

Let us now turn to the data presented by Dr. Canestrari and to his interesting analysis of errors in paired associate learning in terms of the notions of commonality in language use and of the associative value of the members of a given list. I find his studies to be one of the most sophisticated attempts at a detailed analysis of age differences in human learning. Nevertheless, it must be pointed out that his conclusions indicating support for the interference theory of age decrement in learning ability can be valid only if the same stringent assumptions are satisfied which I previously required for Dr. Comalli's data if they are to provide an adequate model for predicting age changes.

The required assumptions for Dr. Canestrari's conclusions then are again the notion that there are no significant differences among successive cohorts and that the effect of environmental change is constant over different periods in time. If one or another of these assumptions cannot be met, one must attribute somewhat different interpretations to the data at hand. Let me do so by scrutinizing the information in Table 4 of Canestrari's paper.

I did not have the details necessary to do the requisite computations, but will assume that the two obviously significant age differences presented by him are for the double-classifications of high-commonality/low association value and for low commonality/low association. First of all note that the error values for both age groups are approximately twice as great for the high commonality as for the low commonality classifications. Next note that while the frequency of previous encounter with the low association list members could indeed be a function of the age of the subjects, it could equally well be accounted for by cohort differences. In other words, it is quite possible that the younger subjects did better with the low association words than did the older because they had greater opportunity to encounter and thus greater cumulative exposure to these words than did the older cohorts. Consequently, the findings in this study could be accounted for by the previously described "improvement of the species" or the "great society" models, in which case neither interference nor degeneration hypotheses would be appropriate explanations for the observed age differences.

I may be accused of being overly critical in my observations, but it seems to me that the time has come to call attention to the flaws inherent in the traditional designs used for the study of aging phenomena, particularly since relatively simple remedies seem now at hand. These remedies do not require lengthy longitudinal studies. All that is needed, is an attempt to measure in addition to age differences, time lag and age changes over relatively brief intervals for all cohorts available to the investigator. Our Figure 1 suggests several appropriate designs for this purpose and since I have elaborated these elsewhere (Schaie, 1965), I shall refrain from taking more of your time. Let me close then by suggesting that great care must be taken to avoid the premature conclusion that the increase in sophistication of our methods has indeed led to a better understanding of how or why organisms age. Thus far it seems just as likely that all we are investigating refers to differences among generations and thus in a changing society to differences which may be as transient as any phase of that society. Only when we have succeeded in differentiating between age changes and age differences can we hope therefore that the provoking methods and findings which we have heard will truly assist us in understanding the nature of the aging process.

References

Bayley, Nancy and Oden, Melitta H. The maintenance of intellectual ability in gifted adults. Journal of Gerontology, 1955, 10, 91-107.

Canestrari, R. E. The effects of age on human learning. Paper read at meeting of the Eastern Psychological Association, Atlantic City, New Jersey, 1965.

Comalli, P. E. Life span developmental studies in perception: Theoretical and methodological issues. Paper read at meeting of the Eastern Psychological Association, Atlantic City, New Jersey, 1965.

Owens, W. A. Age and mental abilities: a longitudinal study. Genetic Psychology Monographs, 1953, 48, 3-54.

Schaie, K. W. A field-theory approach to age changes in cognitive behavior. Vita humana, 1962, 5, 129-141.

Schaie, K. W. A general model for the study of developmental problems. Psychological Bulletin, 1965, in press.

Schaie, K. W. and Strother, C. R. A cross-sequential study of age changes in cognitive behavior. Paper presented at Midwestern Psychological Association, St. Louis. Unpubl. mimeographed paper, University of Nebraska, 1964. (a)

Schaie, K. W. and Strother, C. R. The effect of time and cohort differences upon changes in cognitive behavior. Unpubl. multilith paper, West Virginia University. Also, American Psychologist, 1964, 19, 546 (Abstract). (b)

Schaie, K. W. and Strother, C. R. Models for the prediction of age changes in cognitive behavior. Unpubl. mimeographed paper, West Virginia University. Also, The Gerontologist, 1964, 4, 14 (Abstract). (c)

Figure 1

Example of a Set of Samples Permitting all Comparisons Deducible from the General Developmental Model

Time of Birth (Cohort)	1955	1960	1965
1910	Sample 3 Age 45 $A_1C_3T_1$	Sample 5 Age 50 $A_2C_3T_2$	Sample 6 Age 55 $A_3C_3T_3$
1905	Sample 2 Age 50 $A_2C_2T_1$	Sample 4 Age 55 $A_3C_2T_2$	
1900	Sample 1 Age 55 $A_3C_1T_1$		

Time of Testing

A - Age level at time of testing

C - Cohort level being examined

T - Number of test in series