Cognitive Development in Aging

K. Warner Schaie

Andrus Gerontology Center and

Department of Psychology

University of Southern California

Paper presented at

Conference on

Language and Communication in the Elderly

Boston, Massachusetts

May 5-6, 1979

Cognitive Development in Aging

K. Warner Schaie
University of Southern California

Introduction

The function of this paper is threefold. First, I want to raise a number of methodological cautions which are needed to place into proper perspective some of the interesting findings and interpretations which you have heard yesterday and will continue to hear today. Second, I will present you with a broad overview of what seems to be the state of the art on cognitive development from adulthood into old age as seen from the psychometric point of view. Since the first and second topic can best be related by examining a specific data base, I will, without further apology, draw heavily upon the longitudinal-sequential work done by me and my associates. Third, I will try to relate our work more specifically to the narrower objectives of this conference by examining in some detail the differential developmental course of two primary mental abilities: Verbal Meaning and Word Fluency. The former is a classical marker for crystallized ability and a well-recognized measure of recognition vocabulary; the latter's factorial place is not as clear, but it has a long history as a measure of vocabulary recall. Our examination will therefore involve some reference to the hierarchical model of adult development presented by crystallized-fluid theory as well as the possible relevance of our data to work on memory for meaningful materials involving the reported differential age patterns for recognition and recall as retrieval paradigms.[1]

Some Methodological Cautions

Although these matters have been addressed repeatedly, unfortunately their further repetition and explication remains a required ritual because the age variable remains a matter of many surprises to the initiate and of much misunderstanding and misuse for the new entrant to the field of Gerontology. What I am speaking about is the status of age as an explanatory concept, the distinction between age changes and age differences, the kind of data that can allow inferences with respect to one or the other, and further the matter of how to define our target population, the elderly. I will then make some comments on the interpretation of test norms and other related matters of concern when trying to obtain valid psychometric data on elderly clients or research participants.

Age as an explanatory concept. Let me begin by emphatically stating that chronological age per se cannot "cause" or be the direct antecedent condition for anything. A person's chronological age merely defines the time span from entry into the environment to the date of assessment. Nevertheless, age, like other index variables, may have some utility in defining the probability of occurrence of certain events which have an ordered incremental or decremental sequence at specific life stages. It is important here to distinguish between time-dependent variables, where the point of origin may be a date other than birth, and age-related variables which seem to be ordered for most along the chronological time frame. In principle, however, we must always substitute other causal antecedents whenever we have identified an age change or age difference. In current research practice, it is common to identify variance due to aging as the residual left after that due to more parsimonious sources, such as differences in education, socio-economic status, or health have been eliminated. Indeed, it has often been proposed that chronological age ought to be used as the dependent rather than independent variable, a notion prominent, for example, in discussions of functional age (also see Baltes & Willis, 1977; Schaie & Parr, 1979; Wohlwill, 1973).

Age changes and age differences. Whether or not changes in cognitive behavior in adulthood can indeed be found over specific age ranges is often a matter of understanding the kind of information that can be obtained from different data sets. Most of the older studies involve the cross-sectional method where, at one point in time, individuals are compared from two or more age groups who, by definition, must belong to different birth cohorts and consequently will have had different life experiences. Longitudinal studies, by contrast, compare the same individuals over two or more points in time. The former method confounds ontogenetic change with generational differences; the latter confounds ontogenetic change with the effects of sociocultural change occurring between times of measurement. These confounds are substantial for most behavioral variables. It is therefore unlikely that findings of cross-sectional age differences can agree fully with longitudinal age changes (Schaie, 1965, 1967, 1977). Many age differences reported in the literature could more parsimoniously be interpreted as generational differences, and results from single-cohort longitudinal studies of human behavior are primarily historical accounts of the life history of a particular generation (Schaie, 1972; Schaie & Gribbin, 1975a).

A number of alternative strategies, known as sequential methods, have been suggested to deal with the above problems. These methods make it possible to estimate the effects of age, cohort, and historical period effects more precisely. Those interested will want to consult the references cited above for more detail. Here we wish to reaffirm the notion that results from studies which do not use methods appropriate to the question asked have only limited generalizability. That is, cross-sectional studies are not likely to tell us how individuals have changed in the past, and simple longitudinal studies do not project accurately how people are likely to change in the future.

Should we study aging or the aged. Gerontologists seem to be divided among those whose primary interest is in the process of adult development and others whose major concern is the end product of such development, the elderly. The first group of investigators, therefore, tend to be interested in changes occurring past a maturational asymptote, say in the early 20's, and pursue such changes until that stage, perhaps no later than the early 70's, where a substantial number of individuals can be found that are reasonably free from confounding pathology. The second group of investigators is more likely to begin the study of individuals in their 50's and continue to that age level where assessable subjects can still be found. Botwinick (1977) has suggested that those who focus on the earlier "developmental" ages tend to be proponents of a "no decline" position, while those who focus primarily on the later years generally argue that "decline" is to be found.

The question of major concern, however, is not simply whether decline can be demonstrated on some variables for some individuals; for it must be recognized that there may be some variables on which there is little or no decrement, and that there are some individuals who may show little or no decrement on most variables into very old age (Baltes & Schaie, 1976; Schaie, 1974). What must be clearly in mind then is the question to be asked and the model subsumed (Schaie, 1973). Curiously, however, it is the basic age-function oriented research which can surely rely upon study of that portion of the life span, say beginning with the late 50's where some reliable age changes can be found for at least some variables in many people, while it is the policy-oriented researcher, who must predict population changes in the future, who will be most concerned with the full adult age span in order to discover the generational differences occurring for individuals in young adulthood and midlife in order to predict the characteristics of the elderly of the future.

Another matter related to this issue is that of sample selection. Just as experimental psychologists have often been accused of forging a science of the albino rat and the sophomore psychology student, so have gerontologists based much of their knowledge on inhabitants of nursing homes and domiciliaries, frequenters of senior centers, and for community-based samples of the snow-ball technique. Clearly defined sub-populations with special characteristics are most useful, but they can only contribute much when compared against populations selected by careful stratified random sampling of a reasonably broad universe (also see Schaie, 1978). Preferably, in work with the elderly there should be knowledge as to the research participants' health status. It is only then that the decision can knowledgably be made whether or not one wishes to describe age changes in individuals with an incidence of pathology comparable to that found in the general population, or whether one wants to study a process in samples which are either free from specified pathology (the well elderly) or indeed to assess the influence of a particular disease entity or syndrome, such as cardio-vascular disease (cf. Hertzog, Schaie, & Gribbin, 1978).

The aging of test norms. Practitioners and researchers alike often call for the development of appropriate age norms on common marker variables of cognitive function. Such norms are clearly necessary and desirable, but their user must be cognizent of the fact that before such norms can be meaningful, it must first be established that the test is age appropriate. This matter has been studied for some time with respect to the early developmental stage, but only recently have there been some efforts to develop tests which will retain the construct validity of measures developed for the young while dealing with the response characteristics of the old. What should be stressed here, however, is that there is no assurance that a given test will remain appropriate for a particular age level. Because of changes in cultural content and context, tests do become obsolete rather quickly. However, they may retain their validity for a given population cohort throughout much of their life, while being less appropriate for successive cohorts. Thus, the Wechsler-Bellevue I may be more appropriate for people now in their 70's (who were in the standardization age range for that test in the 30's) than would be the current revision of the WAIS. Also we have found that the 1949 edition of the PMA used in our work has greater validity for older adults than do more recent revisions (Gribbin, Schaie & Stone, 1977).

Let me suggest further that the use of age-corrected norms can be quite misleading when the objective is to obtain some absolute assessment on level of function, whether in an age-neutral in- or out-selection procedure or for the definition of pathology which may be prevalent in old age but is not really consequent to time-dependent processes. For the latter purposes, it may be better to use comparisons with a target population thought to be at an optimal level or meeting minimally acceptable criteria (also see Schaie, 1979; Schaie & Parr, 1979).

Cognitive Development From Adulthood to Old Age

There has been a good deal of recent controversy on the issue of whether and when intellectual abilities decline during the course of young adulthood to old age (cf. Botwinick, 1977; Baltes & Schaie, 1976; Horn & Donaldson, 1976; Schaie & Baltes, 1977). Actually this controversy merely sharpens discussions which have been going on for some time and which depend heavily upon the data base used for ones interpretation. Let me begin this section by giving you what my own conclusions on the state of the art are in the form of some declaratory statements. I will then buttress these statements by a brief review of the literature and a detailed example from my own work.

<u>Current state of the art on the course of adult cognitive development.</u> Here are ~~seven~~ eight summary statements which for me defines the current state of affairs; of course, you may and wish to argue every one of them.

First, intelligence in adulthood does not follow a single course. Reliable decrement for <u>all</u> abilities or <u>all</u> individuals cannot be found until very old age (the late 80's). Second, beginning in mid-life, most individuals show minor decrement on those abilities which involve speed of response. Where measurement is particularly sensitive to relatively modest impairment of the peripheral nervous system, modest decrement will be seen by the early 60's. Third, decrement is also likely to be found on most abilities for individuals with severe cardiovascular disease at any age, and for individuals living in undifferentiated or socially deprived environments by the late 50's and early 60's.

Fourth, longitudinal and repeated-measurement sequential studies accurately estimate age changes for individuals in above average health who live in favorable environmental conditions. Such studies will overestimate maintenance of performance levels for those living under less favorable conditions and in less than average health. Fifth, cross-sectional or independent samples sequential studies tend to exaggerate "normal" age decrements because such studies include individuals who perform at lowered levels, not because of age, but because of ability-related disease and/or life-style variables. Sixth, although age changes in cognitive functions within individuals are small compared to generational differences until the mid-sixties, from then on there is a mix of cohort and age effects, with age effects assuming increasing importance as the 80's are reached. Seventh, in healthy, well-educated populations many older individuals perform within the middle (average) range of young adults. Some adults show decrement on some abilities quite early in life, but others maintain their function well into advanced old age. And eighth, much of what we know about adult intelligence has been learned by studying older individuals with measures developed for the young. The complex interaction between intellectual ability and situational competence in advanced age, therefore, still remains to be explored within an ecologically valid framework.

A brief review of the literature. An early finding of interest to students of adult cognitive development comes from Yerkes (1921) study of World War I soldiers. He reported that the apparent average level of mental function for young adults was only at about 13 years of age. Terman's original standardization of the Binet Intelligence Test for American Use also assumed that intellectual development peaked at age 16 and then remained constant (Terman, 1916). However, Jones and Conrad (1933), on the basis of cross-sectional studies in a New England community, showed substantial age differences across adulthood on some, but little differences on other subtests of the Army Alpha Intelligence Test.

Similar findings were obtained in the standardization studies connected with the development of the Wechsler-Bellevue Intelligence Test. Wechsler (1939) emphasized the fact that growth of intelligence does not end in early adolescence, that peak ages are not the same for different aspects of intellectual functioning, and that age differences are not uniform across the full spectrum of abilities tapped by most of the major batteries measuring intellectual development.

Matters were complicated further by the findings of Bayley and Oden (1955) and of Owens (1953, 1959) that when individuals are followed longitudinally, growth of intelligence or stability continues into midlife.

Much of the cognitive appraisal of older adults in clinical settings has been conducted with one or another version of the Wechsler Adult Intelligence

Test (WAIS). Normative data for older persons on this test are therefore of considerable interest. The Wechsler tests first appeared in 1939, although normative data for individuals beyond age 60 were not published until 1955 (Doppelt & Wallace, 1955). Table 1 (adapted from Matarazzo, 1972, p. 354) lists age differences from early adulthood to late middle age. These age differences are consistent but not particularly remarkable considering that the mean of the standardization group is 10 and its standard deviation 3. Those differences which approach significance involve measures which are speeded suggesting that constant time intervals become less and less adequate for the equitable assessment of psychological constructs in successive age groups. No significant age differences occur over the entire mid-life period for the power tests Information, Comprehension, Arithmetic, Similarities, and Vocabulary. Until 60 or so, there is virtually no drop for the Verbal Scale, but quite a sharp drop prevails on the Performance Scale.

Insert Table 1 about here

Norms for the WAIS for ages 65 and older have been reported by Doppelt and Wallace (1955). These norms do show significant drop, even for the verbal scales, past the age of 70. Substantial drop is most noteworthy again for the performance (speed implicated) measures. The verbal/performance discrepancy seems well replicated and has been found across the sexes, racial groups, and different socio-economic levels (Eisdorfer, Busse & Cohen, 1959), and greater than average drop in performance IQ has been implicated as a predictor of survival (Hall et al., 1972).

While cross-sectional age comparisons of the WAIS imply speed-related age decrements beyond the 50's, it has generally been maintained that verbal performance on the WAIS continues unimpaired into old age. Botwinick and Storandt

(1974) recently challenged this notion by giving the WAIS vocabulary test to individuals ranging in age from 62 to 83 years who were matched on quantitative scores on that test. Qualitative scoring revealed that the younger subjects excelled in superior synonyms (the only scoring category yielding an age difference). In a later study (Botwinick, West & Storandt, 1975) the authors concluded, nevertheless, that qualitative and quantitative age differences in Vocabulary performance did not differ except for fine meaning nuances.

Longitudinal data on changes in WAIS scores over a ten-year period have been reported by Eisdorfer and Wilkie (1973) for persons in their 60's and 70's each tested four times. Only an average of 2 score points for the Performance and 0.6 score points for the Verbal Scales were lost over the ten years between the 60's and 70's. The larger total loss of 7.3 score points from the 70's to the 80's was about equally divided between the Verbal and Performance Scales. Declines from the mid-sixties into the 80's have also been reported in a 20-year study by Blum, Fosshage and Jarvik (1972). By contrast, other studies on highly selected groups report little or no drop on Vocabulary even into very advanced age (Gilbert, 1973; Green, 1969). Further discussions of the Wechsler test and its limitations in older populations may be found in Botwinick (1977), Schaie (1979c), and Schaie and Schaie (1977).

The Wechsler sub-tests are factorially complex. A clearer picture may perhaps be obtained from age difference data for the more clearly defined Primary Mental Abilities (Thurstone & Thurstone, 1949). Figure 1 presents results of the first parametric study for this test over the age range from early adulthood to early old age (Schaie, 1958). Five abilities were systematically assessed. These are Verbal Meaning, a measure of recognition vocabulary; Space, the ability to visualize mentally the rotation of geometric objects; Reasoning, a measure of the ability to identify rules and serial principles; Number, a test of numerical skills; and Word Fluency, a measure of vocabulary recall. The data shown here come from a study of 25 men and 25 women randomly selected in each five year interval from 20 to 70 from the membership of a large metropolitan health care plan. Only insubstantial age differences occur until about age 50 for Space, Reasoning, and Verbal Meaning and until age 60 for Number and Word Fluency. For the latter, even at 70 the drop from peak does not exceed one standard deviation. Note also that adult ability peaks appear to be located primarily in the 31 to 35 year old group (for further discussion of historical changes in adult ability peaks see Schaie, 1970).

Insert Figure 1 about here

As was noted earlier, cross-sectional studies confound age changes with generational differences. It becomes important therefore to examine age trends determined by following samples of the same individuals over time supplemented by longitudinal studies based on independent samples, i.e., successive samples drawn from the same birth cohort at different ages but each tested only once. Such data were obtained by retesting members of our 1956 samples after 7, 14, and 21 years and obtaining new panels in 1963, 1970, and 1977 from the same population frame. The 1963 panel has been retested in 1970 and 1977, and the 1970 panel was retested in 1977.

From these data, let me first give you an example for the Verbal Meaning (recognition vocabulary) test for the initial 14 years of our sequential study, based upon the analysis of data for 300 persons followed from 1956 to 1963, 409 persons followed from 1963 to 1970, and 162 persons followed over the 14 years from 1956 to 1970 (Schaie & Labouvie-Vief, 1974). Figure 2 plots the requisite data along a chronological age scale. The upper left quadrant of

----

Insert Figure 2 about here

----

this figure shows the 1956 and 1963 cross-sectional studies as solid lines and the seven-year longitudinal studies as dotted lines. Note that there are gains for the younger cohorts up to age 60, with some drop beyond that point. The lower left quadrant shows the replication of this study for the second sample followed from 1963 to 1979. The data are very similar except that drop does not occur before age 67. The upper right quadrant shows the cross-sectional gradients for the three tests occasions. These gradients lie on top of each other in orderly sequence, suggesting increments for younger cohorts at many ages. The lower left quadrant is perhaps the most interesting. The data shown there can be conceptualized as the simultaneous longitudinal study from 1956 to 1970 of seven cohorts, successively differing by seven years in average date of birth. The youngest cohort (average birth year 1938) is followed from mean age 25 to 39; the oldest cohort (average birth year 1889) is followed from age 67 to age 81, and so on. Note the prevalence of gain or stability until age 60, modest decline until 74, and steeper decline over the last seven-year period. Also note the obvious differences in cohort level, particularly the gap between the fourth and the fifth cohort.

Similar findings occurred for the other abilities studied. Statistically reliable decrement over a 14-year period was found for Space and Reasoning only for the oldest cohort from age 67 to age 81. No reliable 14-year change was found for Number. As shown above, reliable age decrement for Verbal Meaning occurred for the two oldest cohorts beginning with age 60. For Word Fluency, however, decrement was found for all but the two youngest cohorts, beginning from age 39 to 53. I will look at this discrepancy in development for our two vocabulary tests in the final section of this paper. Before doing so, however, I wish to call attention to the distinction between statistically reliable and practically significant age change.

Cumulative age changes in adult cognitive development. Although the statistically reliable age changes found in our work appear rather late, attention has been called by some critics (Horn & Donaldson, 1976) that the trend towards decrement may actually start earlier. I have tried to address this issue by computing cumulative age changes based on the average within subject changes from the 362 participants for whom 14-year data were available (Schaie and Hertzog, 1979). I have argued earlier (Schaie, 1979a; Schaie & Parham, 1977) that the practical implications of age change in cognitive function is best communicated when performance is charted as successive ages as a proportion of performance at a base age. In Table 2, I am showing you performance indices for ages 32 to 81, where 100 is the average performance level at age 25. Note that by this criterion performance does not drop below the young adult level for Verbal Meaning until age 81, for Space, Reasoning and Number until age 74, but for Word Fluency it does drop by age 60.

Merely checking whether average performance remains at the young adult average level may still be a too severe criterion to be of clinical utility. A more lenient criterion is suggested by psychometric tradition which assumes that performance within the middle 50 percent of the population is thought to be characteristic of average performance (cf. Matarazzo, 1972, pp. 124-126). The lower bound of this average range (25th percentile) denotes the level below which an older group should fall before it can be argued that there has been sufficient decrement to conclude that the average member of the older group falls below the average range of the young comparison group. Table 2 indicates that a decrement of such magnitude is reached for Word Fluency at age 74, for Verbal Meaning and Number by age 81, but that the average 81-year-old in our panel is still within the average range of 25-year-olds on Space and Inductive Reasoning.

Insert Table 2 about here

The Case of Vocabulary Recognition and Recall

The data and conclusions discussed above are, of course, not new and were merely restated at the request of the conference organizers to provide general background on cognitive development in aging. In this last section, I am reporting some new analyses which I hope will relate directly to the objectives of this conference. I have chosen to consider the very different developmental course of two of the variables systematically monitored over age and cohorts in our longitudinal study which seem to be most relevant to language behavior. These are, of course, Verbal Meaning and Word Fluency.

There are a number of cogent reasons why one would expect diverging life courses for these abilities. But in the empirical literature, thus far, most of these premises have failed to receive proper attention because of the very different age patterns found in cross-sectional and longitudinal studies. First let me indicate the theoretical status of Verbal Meaning and Word Fluency within the context of current psychometric thinking.

Verbal meaning. Within Guilford's (1967) structure of intellect model, this is defined as a prime example of "Cognitive Semantic Units." Within the crystallized-fluid model of Horn and Cattell (1966) it is an unambiguous marker of crystallized intelligence (Gc) (Horn, 1978), although in earlier discussions (Horn, 1970) some minor loading on a Fluency factor (F) had been suggested. Some further analysis suggests that the task of matching a stimulus word with a correct analogy from a set of multiple choices must also involve long-term memory for meaningful material as measured by a recognition paradigm. In this sense, developmental differences in performance would likely be affected by average cohort asymptotes in the acquisition of the vocabulary items contained in the test, but also by possible changes in the strength of the memory trace and in the operation of response bias (Kintsch, 1970). To the extent that there is little evidence of age-related decrement in memory trace when a recognition task is involved (Craik, 1977), I would suggest that age differences on Verbal Meaning should primarily reflect cohort differences in vocabulary content (also see Gardner & Monge, 1977), while the small observed age changes are likely to be accountable as a function of unfavorable response bias and cautiousness (Birkhill & Schaie, 1975).

Word fluency. Within Guilford's schematic this variable is designated as a marker for "Divergent-productive Symbolic Units." Earlier work by Horn and Cattell (1967) would assign Word Fluency to a simple Fluency factor. More recently, however, Horn (1978) has elected to distinguish a verbal productive thinking factor (VPT) which seems quite similar to Guilford's description and which would seem to fit the salient characteristics of our Word Fluency task. It is important to mention here that while Verbal Meaning merely requires the matching of a stimulus to a limited number of matching alternatives, Word Fluency essentially requires minimally cued recall. According to Kintsch (1970) recall involves a search and retrieval process, the efficiency of which may depend upon how well the material has been organized in memory. Since the task in Word Fluency is to recall words beginning with a given letter of the alphabet, structural cues are quite limited. Younger individuals would tend to superimpose search strategies, such as looking for numbers, names, household objects, or the like starting with that letter, while older subjects are known to be less likely to use efficient classification strategies (for a detailed review of these issues see Schaie & Zelinski, 1979). It follows then that we would expect adverse age changes in recall with increasing age, an observation supported by much of the literature on aging and memory (Craik, 1977), but such changes might not clearly be seen in cross-sectional studies because of concomitant adverse generation effects in educational practices which require memorization of verbal materials.

Empirical data. To assess the above predictions, I have examined cross-sectional data on 2810 individuals over the age range from 22 to 84 years of age arranged in sub-groups by sex and age groups in seven year intervals with mean ages from 25 to 81 years. These subjects were tested in the four waves of our longitudinal-sequential study from 1956 to 1977, and, of course, greater stability is obtained at the price of averaging at each age over four cohorts and times of measurement. Table 3 provides means and sub-sample sizes by sex and age for subjects combined across the sexes. Age differences then behave

----

Insert Table 3 about here

----

as predicted with overall differences between youngest and oldest group amounting to approximately 1.7 standard deviations for Verbal Meaning, but only 1.1 standard deviations for Word Fluency. Women are slightly superior to men on both variables at all ages. Their range of age differences is similar to that for men for Verbal Meaning, but somewhat smaller for Word Fluency (1 S.D. as compared to 1.3 S.D.).

The next step was to estimate comparable longitudinal age changes. This was done by relying upon the most stable of our longitudinal samples, those 120 individuals on whom four assessment points were available. Age differences were averaged over all individuals available for a particular seven year interval in order to average out cohort differences. Table 4 provides the resulting estimates and the number of subjects upon which each data point is based.

Insert Table 4 about here

These results again are in line with our predictions. Verbal Meaning appears to increase until age 60, with some modest decrement thereafter perhaps due to the slightly speeded nature of this test, but the longitudinal change from the youngest to the oldest age is only a third of a standard deviation, and decline from adult peak about two-thirds S.D. Word Fluency, on the other hand, declines as much as 1.4 S.D., or twice as much. Interesting sex differences are also found. Women at all ages are better than men on Verbal Meaning, but women show greater loss than men on Word Fluency. Figure 3 illustrates these sex differences, showing the increasing divergence in performance on the active recall from the passive recognition vocabulary, a divergence which appears to be greater for women than for men. Finally, Figure 4 will bring home graphically the importance of distinguishing the kind of information to be obtained from longitudinal and cross-sectional data bases, showing the substantial divergence and in fact cross-over of results using either approach.

Insert Figures 3 and 4 about here

Summary

I have tried to call attention in this paper to some of the methodological problems which trouble our clear understanding of results of studies of human cognition from young adulthood into old age. After reviewing some of the literature on age differences and changes in psychometric intelligence, I concluded that substantial generational differences, but little consequential ontogenetic change, was to be found until age 60. Beyond that age, however, progressive developmental change must be expected at least on some variables, although the cumulative magnitude and practical significance of such changes may still be quite modest. Finally, I examined some data on recognition and recall vocabulary, concluding that there were positive generational differences on the former but negative generational differences on the latter, and further that age changes were minimal on recognition vocabulary but large on recall vocabulary, a difference more pronounced among women than men.

References

Baltes, P. B., & Schaie, K. W. On the plasticity of intelligence in adulthood and old age: Where Horn and Donaldson fail. American Psychologist, 1976, 31, 720-725.

Baltes, P. B., & Willis, S. L. Toward psychological theories of aging and development. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold, 1977.

Birkhill, W. R., & Schaie, K. W. The effect of differential reinforcement and intellectual performance of the elderly. Journal of Gerontology, 1975, 30, 578-583.

Bayley, N., & Oden, M. H. The maintenance of intellectual ability in gifted adults. Journal of Gerontology, 1955, 10, 91-107.

Blum, J. E., Fosshage, J. L., & Jarvik, L. F. Intellectual changes and sex differences in octagnarians: A twenty-year longitudinal study of aging. Developmental Psychology, 1972, 7, 178-187.

Botwinick, J. Intellectual abilities. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinbold, 1977.

Botwinick, J., & Storandt, M. Vocabulary ability in later life. Journal of Genetic Psychology, 1974, 125, 303-308.

Botwinick, J., West, R., & Storandt, M. Qualitative vocabulary test response and age. Journal of Gerontology, 1975, 30, 574-577.

Craik, F. I. M. Age differences in human memory. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Von Nostrand Reinhold, 1977.

Doppelt, J. E., & Wallace, W. L. Standardization of the Wechsler Adult Intelligence Scale for older persons. Journal of Abnormal and Social Psychology, 1955, 51, 312-330.

Eisdorfer, C., Busse, E. W., & Cohen, L. D. The WAIS performance of an age sample: The relationship between verbal and performance IQ's. Journal of Gerontology, 1959, 14, 197-201.

Eisdorfer, C., & Wilkie, F. Intellectual changes with advancing age. In L. F. Jarvik, C. Eisdorfer, & J. E. Blum (Eds.), Intellectual functioning in adults. New York: Springer, 1973, pp. 21-29.

Gardner, E. F., & Monge, R. H. Adult age differences in cognitive abilities and educational background. Experimental Aging Research, 1977, 3, 337-383.

Gilbert, J. G. Thirty-five year follow-up study of intellectual functioning. Journal of Gerontology, 1973, 28, 68-72.

Green, R. F. Age-intelligence relationship between ages sixteen and sixty-four: A rising trend. Developmental Psychology, 1969, 1, 618-627.

Guilford, J. P. The nature of human intelligence. New York: McGraw-Hill, 1967.

Hall, E. H., Savage, R.D., Bolton, N., Pidwell, D. M., & Blessed, G. Intellect, mental illness, and survival in the aged: A longitudinal investigation. Journal of Gerontology, 1972, 27, 237-244.

Horn, J. L. Organization of data on life-span development in human abilities. In L. R. Goulet & P. B. Baltes (Eds.), Life-span developmental psychology: Research and theory. New York: Academic Press, 1970, pp. 424-467.

Horn, J. L. Human ability systems. In P. B. Baltes (Ed.), Life-span development and behavior (Vol. 1). New York: Wiley, 1978.

Horn, J. L., & Cattell, R. B. Refinement and test of the theory of fluid and crystallized intelligence. Journal of Educational Psychology, 1966, 57, 223-270.

Horn, J. L., & Cattell, R. B. Age differences in fluid and crystallized intelligence. Acta Psychologica, 1967, 26, 107-129.

Horn, J. L., & Donaldson, G. On the myth of intellectual decline in adulthood. American Psychologist, 1976, 31, 701-719.

Jones, H. E., & Conrad, H. S. The growth and decline of intelligence: A study of a homogenous group between the ages of ten and sixty. Genetic Psychology Monographs, 1933, 13, 223-298.

Kintsch, W. Learning, memory, and conceptual processes. New York: Wiley, 1970.

Matarazzo, J. D. Wechsler's measurement and appraisal of adult intelligence. Baltimore: Williams & Wilkins, 1972.

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

Owens, W. A., Jr. Is age kinder to the initially more able? Journal of Gerontology, 1959, 14, 334-337.

Schaie, K. W. Rigidity-flexibility and intelligence: A cross-sectional study of the adult life-span from 20 to 70. Psychological Monographs, 1958, 72, No. 462 (Whole No. 9).

Schaie, K. W. A general model for the study of developmental problems. Psychological Bulletin, 1965, 64, 92-107.

Schaie, K. W. Age changes and age differences. Gerontologist, 1967, 7, 128-132.

Schaie, K. W. A reinterpretation of age-related changes in cognitive structure and functioning. In L. R. Goulet & P. B. Baltes (Eds.), Life-span developmental psychology: Research and theory. New York: Academic Press, 1970.

Schaie, K. W. Can the longitudinal method be applied to studies of human development? In F. Z. Moenks, W. W. Hartup, & J. DeWitt (Eds.), Determinants of behavioral development. New York: Academic Press, 1972.

Schaie, K. W. Methodological problems in descriptive developmental research on adulthood and aging. In J. R. Nesselroade & H. W. Reese (Eds.), Life-span developmental psychology: Methodological issues. New York: Academic Press, 1973.

Schaie, K. W., & Parham, I. A. Cohort-sequential analyses of adult intellectual development. Developmental Psychology, 1977, 13, 649-653.

Schaie, K. W., & Parr, J. Concepts and criteria for functional age. In M. Marois (Ed.), Aging: A challenge for science and social policy. Oxford: Oxford University Press, 1979, in press.

Schaie, K. W., & Schaie, J. P. Clinical assessment and aging. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold, 1977.

Schaie, K. W. & Willis, S. L. Life-span development: Implications for education. Review of Research in Education, 1978, 6, 120-156.

Schaie, K. W., & Willis, S. L. Maintenance and decline of adult mental abilities: I. Empirical data and explanatory models. In F. Grote (Ed.), Western Washington University ninth symposium on learning: Adult learning and development. Bellingham, Washington, 1979, in press.

Schaie, K. W., & Zelinski, E. Psychometric assessment of learning and memory dysfunctions in the elderly. In F. Hofmeister (Ed.), Brain function changes in normal and abnormal aging. Essen, Germany: Bayer, 1979, in press.

Terman, L. M. The measurement of intelligence. Boston: Houghton, 1916.

Thurstone, L. L., & Thurstone, T. G. Examiner manual for the SRA Primary Mental Abilities test. Chicago: Science Research Associates, 1949.

Wechsler, D. The measurement of adult intelligence. Baltimore: Williams & Wilkins, 1939.

Wohlwill, J. F. The study of behavioral development. New York: Academic Press, 1973.

Yerkes, R. M. Psychological examining in the United States Army. Memoirs of the National Academy of Sciences, 1921, 15, 1-890.

Schaie, K. W. Translations in gerontology--From lab to life: Intellectual functioning. American Psychologist, 1974, 29, 802-807.

Schaie, K. W. Quasi-experimental designs in the psychology of aging. In J. E. Birren & K. W. Schaie (Eds.), Handbook of the psychology of aging. New York: Van Nostrand Reinhold, 1977.

Schaie, K. W. External validity in the assessment of intellectual assessment in adulthood. Journal of Gerontology, 1978, 33, 695-701.

Schaie, K. W. The Primary Mental Abilities in adulthood: An exploration in the development of psychometric intelligence. In P. B. Baltes & O. B. Brim, Jr. (Eds.), Life-span development and behavior (Vol. 2). New York: Academic Press, 1979a.

Schaie, K. W. Intellectual development in adulthood. In R. D. Sprott (Ed.), Intelligence and aging. New York: Van Nostrand Reinhold, 1979b, in press.

Schaie, K. W. Intelligence and problem solving. In J. E. Birren & R. B. Sloane (Eds.), Handbook of mental health and aging. Englewood Cliffs, NJ: Prentice Hall, 1979c, in press.

Schaie, K. W., & Baltes, P. B. Some faith helps to see the forrest: A final comment on the Horn and Donaldson myth on the Baltes-Schaie position on adult intelligence. American Psychologist, 1977, 32, 1118-1120.

Schaie, K. W., & Gribbin, K. Adult development and aging. Annual Review of Psychology, 1975, 26, 65-96.

Schaie, K. W., & Hertzog, C. Estimates of ontogenetic change in intelligence during adulthood: A 14-year cohort-sequential study. Unpublished manuscript, University of Southern California, 1979.

Schaie, K. W., & Labouvie-Vief, G. V. Generational versus ontogenetic components of change in adult cognitive behavior: A 14-year cross-sequential study. Developmental Psychology, 1974, 10, 305-320.

Footnote

[1]Coverage of the first two objectives has been provided more extensively elsewhere and involves the restatement of material in Schaie, 1973, 1977, 1978, 1979a, 1979b, 1979c and in Schaie & Willis, 1978, 1979. Data reported in this paper were obtained in a project supported in part by research grant AG 00480 from the National Institute of Aging. The cooperation of Group Health Cooperative of Puget Sound is gratefully acknowledged.

Table 1

Mean Scores by Age for Sub-test Performance on the WAIS During Middle Adulthood (Each mean is based on N=200)

Sub test	20-24	25-34	35-44	45-54	55-64
VERBAL SCALE					
Information	9.8	10.3	10.3	9.9	9.9
Comprehension	10.0	10.2	10.2	9.9	9.6
Arithmetic	10.0	10.1	10.2	9.8	9.4
Similarities	10.2	10.1	9.2	9.0	9.0
Digit Span	9.9	10.0	9.6	9.0	8.4
Vocabulary	9.6	10.3	10.4	10.1	10.1
PERFORMANCE SCALE					
Digit Symbol	10.1	9.9	8.5	7.5	6.3
Picture Completion	10.1	10.0	9.8	8.6	8.0
Block Design	9.9	10.0	9.4	8.5	7.7
Picture Arrangement	10.5	9.7	9.1	8.0	7.3
Object Assembly	10.1	10.0	9.3	8.5	7.8

Adapted from Table 12.11 from Matarazzo (1972, page 354) by permission of the author and publisher

Table 2

Estimated Performance Level as a Proportion of Performance at Age 25 Based on Cumulative Age Changes

(Decimals omitted; 100 = Average or 25 year old comparison group)

Variable	32	39	46	53	60	67	74	81	25th% tile @ Age 25
Verbal Meaning	108	110	112	112	113	108	102	85	36
Space	109	111	112	113	110	101	94	85	78
Reasoning	109	110	108	108	109	106	94	85	81
Number	116	111	114	107	108	100	93	70	74
Word Fluency	101	103	104	100	97	92	84	74	86

Table 3

Cross-sectional Age Pattern for the Primary Mental Abilities of VERBAL MEANING and WORD FLUENCY

	Males			Females			Total		
Age	V	W	n	V	W	n	V	W	n
25	53.2	52.6	139	54.9	53.7	163	54.1	53.2	302
32	54.0	50.9	142	55.8	55.5	177	55.0	53.4	319
39	54.5	51.5	178	54.1	52.3	200	54.3	51.9	378
46	52.3	50.6	190	54.1	52.6	186	53.2	51.8	376
53	51.4	50.1	177	51.2	51.6	202	51.3	50.9	379
60	48.4	48.6	166	49.3	50.6	180	48.9	49.6	346
67	43.5	45.1	179	45.3	46.2	188	44.4	45.7	367
74	39.6	41.6	121	41.5	44.2	114	40.5	42.8	235
81	36.7	39.7	53	37.4	44.1	55	37.0	41.9	108

All scores were scaled to a mean of 50 and standard deviation of 10 for the entire sample.

Table 4

Longitudinal Age Pattern for the Primary Mental Abilities of VERBAL MEANING and WORD FLUENCY

	Males			Females			Total		
Age	V	W	n	V	W	n	V	W	n
25	52.0	51.6	8	57.2	53.4	9	54.8	52.6	17
32	54.4	52.3	15	58.3	50.6	19	56.5	52.1	34
39	55.8	50.5	24	60.5	47.9	31	58.2	48.8	55
46	56.5	47.8	39	59.1	47.9	44	57.8	47.7	83
53	57.1	47.1	41	59.6	45.5	48	58.4	46.9	89
60	57.9	45.3	36	59.7	44.1	45	58.8	44.9	81
67	54.1	46.0	30	57.1	42.0	35	55.6	44.0	65
74	52.2	43.6	15	55.2	40.0	22	53.7	41.9	37
81	48.0	41.1	5	54.2	37.2	9	51.6	39.2	14

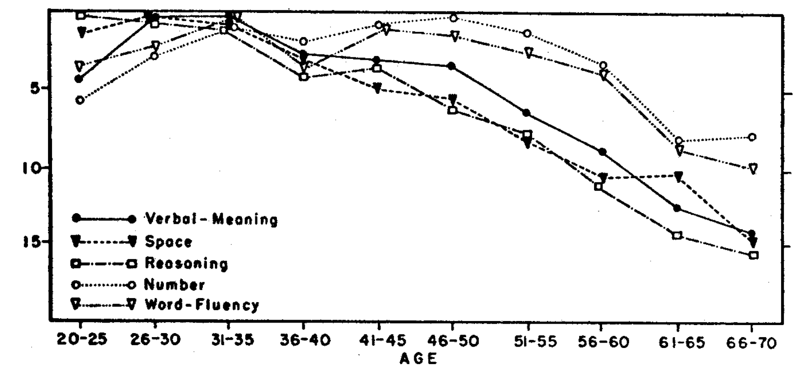
Figure Captions

Figure 1. Mean decrement in the primary mental abilities from mean peak level in T-score points from cross-sectional data (From Schaie, 1958. Copyright by the American Psychological Association. Reproduced by permission).

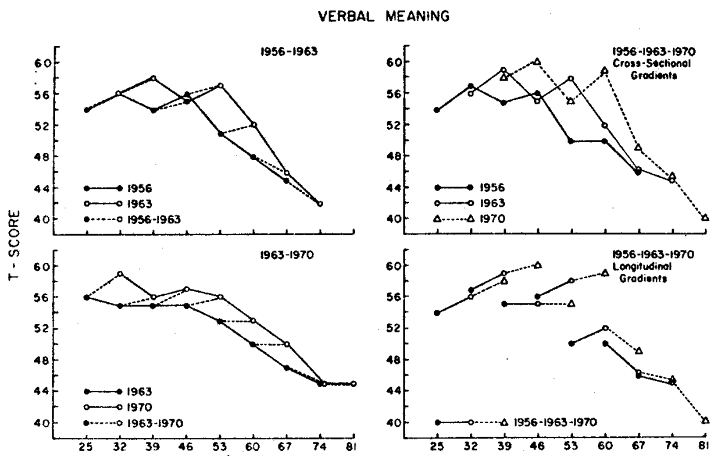
Figure 2. Mean scores for verbal meaning from the fourteen-year longitudinal study (From Schaie & Labouvie-Vief, 1974. Copyright by the American Psychological Association. Reproduced by permission).

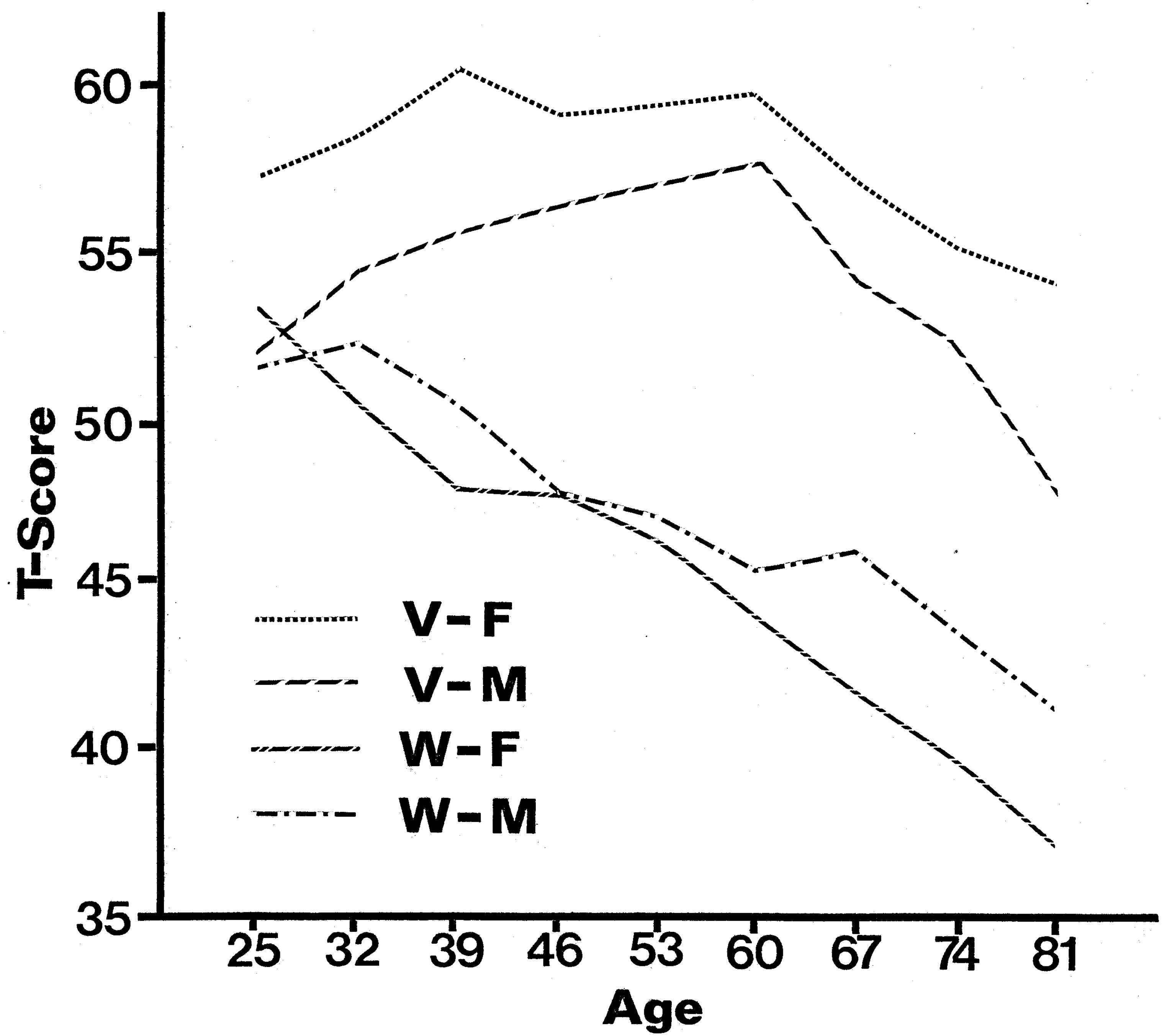
Figure 3. Cumulative change with age on verbal meaning and word fluency by sex estimated from twenty-one-year longitudinal data.

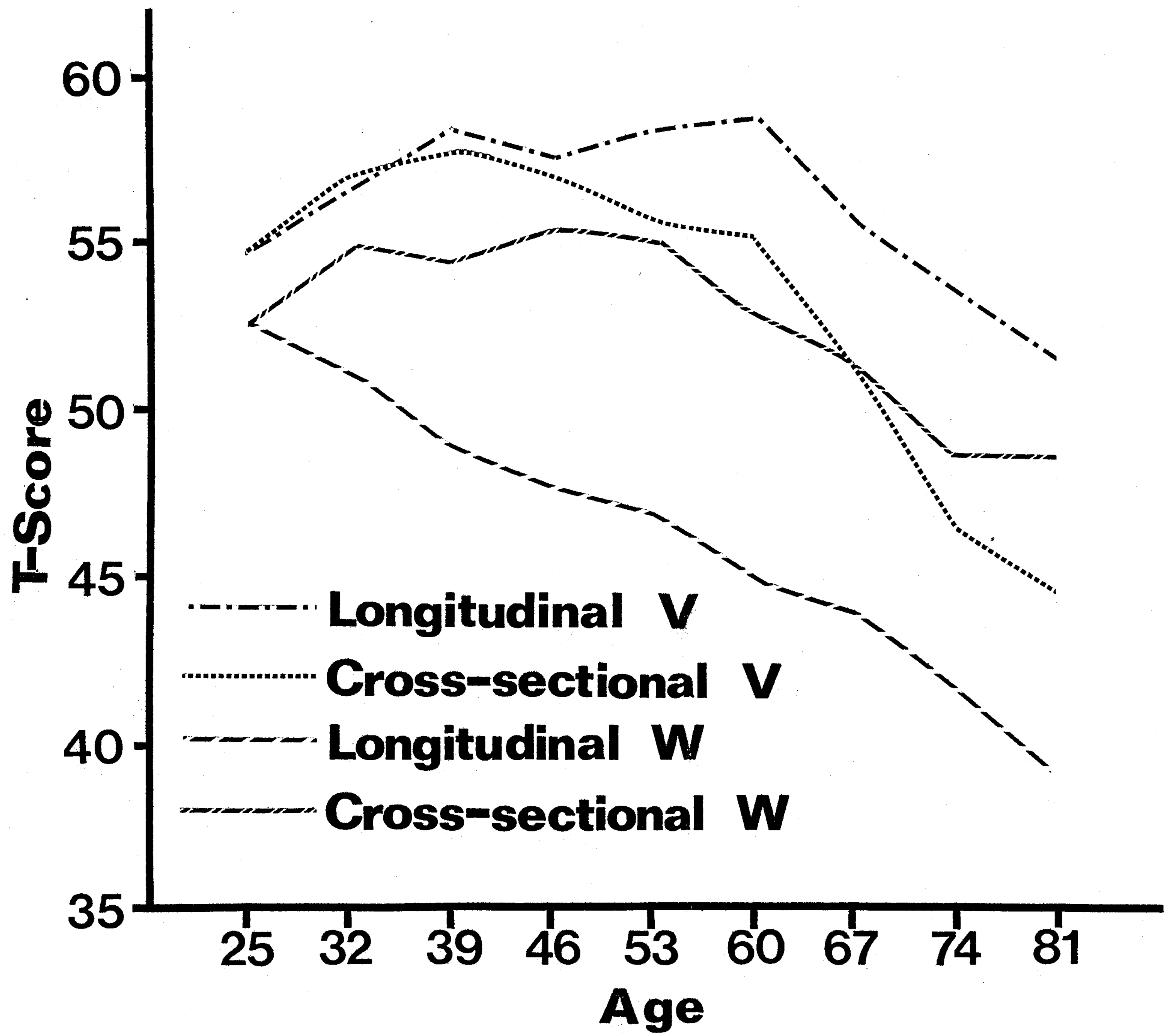
Figure 4. Comparison of cross-sectional and longitudinal data on age changes and differences on verbal meaning and word fluency.



5
10
15
Verbal - Meaning
Space
Reasoning
Number
Word - Fluency
20-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
AGE


VERBAL MEANING
T - SCORE
1956-1963
1956
1963
1956-1963
1956-1963-1970
Cross-Sectional
Gradients
1956
1963
1970
1963-1970
1963
1970
1963-1970
1956-1963-1970
Longitudinal
Gradients
1956-1963-1970
60
56
52
48
44
40
25
32
39
46
53
60
67
74
81


T-Score
60
55
50
45
40
35
25
32
39
46
53
60
67
74
81
Age
V - F
V - M
W - F
W - M


T-Score
60
55
50
45
40
35
25
32
39
46
53
60
67
74
81
Age
Longitudinal V
Cross-sectional V
Longitudinal W
Cross-sectional W