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ABSTRACT

Recent publications of longitudinal and sequential analyses of psychometric data have been cited as evidence for "the myth of intellectual decline" with age. This term "myth" has been interpreted by many gerontologists to mean that intellectual functioning does not decline even late in life (except shortly before death). Furthermore, this interpretation of maintenance of functioning has been generalized to other cognitive performance. Learning and memory data from the Baltimore Longitudinal Study have been analyzed. Laboratory measures of serial and paired-associate learning and performance on the Benton Revised Visual Retention test indicate that verbal learning and memory-for-designs decline late in life. The primary results are based on pairs of measures at least six years apart of men over the entire adult range. These results were supported by comparisons of two independent samples from each of several birth cohorts. The two samples were measured at different times and provided estimates of age changes within cohorts. The samples measured later were older than the early samples; and for the groups late in life, performance favored the younger samples. The participants in this study are predominantly educated healthy men. These findings are not consistent with the hypothesis of maintenance of cognitive performance late in life. (Author)

Changes With Age in Learning and Memory

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Presidential Address

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I am going to take this opportunity today to tell you about some findings from the Baltimore Longitudinal Study. I will focus primarily on verbal learning data, but I will include some memory-for-designs data as well. I had several reasons for deciding to talk about these findings today. First, they have not been published and have not been presented at meetings, so I wanted to share them with you. But more important is my concern about a certain kind of thinking that has become so prevalent among gerontologists in recent years with regard to cognitive performance. There is a widespread acceptance that intellectual performance does not decline with advancing age. This is sometimes qualified by excluding highly speeded tasks, and sometimes a short period preceding death is excluded. Nevertheless, a general belief prevails that intellectual performance does not decline, probably based mostly upon the longitudinal findings of Dr. Warner Schaie and his colleagues. Their results are frequently characterized by the term "the myth of intellectual decline."

Unfortunately, it is easy to use the term "cognitive performance" for "intellectual performance." This is a short step away from "cognitive decline" instead of "intellectual decline." Then we have people believing that memory and learning and reasoning do not decline with advancing age. I understand that in formal presentations at recent meetings of the APA and the Gerontological Society cross-sectional age differences in learning and memory have been dismissed as cohort effects.

The idea that our intellect is maintained when we get old is extremely appealing. But I believe it is wrong! Please note that I am not referring only to a speed factor. I am talking about learning, and memory, and problem solving -- those aspects of behavior we value so much. And, if important aspects of intellect decline when we get old, then we in the field of adult development and aging had better face up to it.

Before we get into the Baltimore Longitudinal Study, I would like to comment briefly on the published longitudinal findings which fostered the "myth of intellectual decline." As you know, the intelligence measures Dr. Schaie and his colleagues used were the five subtests of the Primary Mental Abilities. Two longitudinal papers appeared in 1968. In one, the same subjects were compared in a repeated-measures design; in the other, independent samples from the same birth cohorts were tested at two different times and compared. In 1973 and 1974, the results of the third time of measurement were reported, and again the repeated-measures approach was used in one study, and the independent-samples approach was used in the other.

The investigators interpreted their data as evidence for maintenance of intellectual performance with age. However, by focusing on the groups 60 or older at first testing a rather different picture emerges. For every subtest, virtually without exception, every comparison of these oldest groups showed declines. In the two papers involving longitudinal measures of the same sample, the groups 60 or older showed mean declines over 7 years or 14 years. In the two papers involving independent samples from the same birth cohort, for the cohorts 60 or older at the first time of measurement, the older sample means were lower than the younger sample means. These mean age declines typically were not large, but the consistency of the declines is extremely impressive. In 45 comparisons covering a 7-year interval and in 20 comparisons covering a 14-year interval, virtually every mean difference and every mean change showed a decline.

So we see that if we focus on the oldest groups in the longitudinal studies reported by Dr. Schaie and his colleagues, evidence can be found for age declines, even in the psychometric data.

But what about learning and memory performance? Do they decline with age? I will spend the remaining time attempting to answer those questions. But I don't want to keep you in suspense. I believe the answer is "yes."

First a little historical background. The Baltimore Longitudinal Study began under Dr. Shock's direction in 1958. I joined the staff at the Gerontology Research Center in 1960 and had a unique opportunity. The participants were scheduled to come in every year and a half, but not every procedure was repeated every visit. As a result, especially in the early 60s, it was possible to add new procedures to the study. So late in 1960, two verbal-learning studies were added: paired-associate learning, and serial learning. Also at the same time, the Benton Visual Retention Test was added; this is a test of memory-for-designs. Before I go into detail to describe these tasks, I would like to say a few words about the subjects.

The participants in the program are all men who range in age over the entire adult span, but the vast majority are between 30 and 80. Intake has been gradual beginning in 1958 and continues even now for selected age groups. The sample is described as self-recruited. The initial nucleus was recruited by one man, Dr. Peter, who solicited his neighbors in Scientists Cliffs, (Md.) and his colleagues from the Department of Agriculture. They, in turn, recruited their colleagues and friends, and that is how most of the participants came into the program. As a result, the subjects are, for the most part, educated men including a high proportion of scientists, professionals, and administrators.

The primary comparisons we will look at involve cross-sectional and conventional, repeated-measures, longitudinal data for the men whose performances were measured initially between late 1960 and mid-1964. The measures were repeated at least six years later.

Now I will describe briefly the paired-associate procedures and then we will take a look at the first slide. The eight items in the list used for the first measure consisted of two consonants and a familiar two-syllable adjective, e.g., TL INSANE. (The list came from a previously published study of aging by Gladis & Braun.)

An experimentally manipulated independent variable is rarely introduced into a longitudinal study unless it is a within-subject variable. In other words, one might use several input conditions in a longitudinal memory study if all subjects receive all of the conditions; but if each subject is randomly assigned to one of two or more conditions, then the sample must be divided into two or more subsamples. I was naive enough and optimistic enough in 1960 to do just that for the learning studies. Each subject was assigned to one of two pace conditions. The period that was varied was the anticipation interval which is the time the subject is given to respond before the correct response is presented.

So in the paired-associate procedure, the two consonants were presented for 1.9 seconds for half the subjects and 3.7 seconds for the other half. Two other time intervals were constant for all subjects, i.e., time to inspect the consonants together with the word and also the interval between items. The list was presented in five different orders until one errorless trial or for 52 trials. The dependent measure was the total number of errors.

Let's look at the first slide (Figure 1) which presents the paired-associate data at the short interval, i.e., the fast pace. The figure is more complicated than I would like, but hopefully I will be able to make it understandable. The initial cross-sectional data showed small age differences for the youngest groups, and large age differences for the oldest groups.

The longitudinal data are shown by pairs of solid triangles connected by dashed lines. For those subjects in a group who returned and for whom a second measure was obtained, the mean number of errors at the two times of measurement are connected by a dashed line. Mean changes for the youngest groups were small, but the oldest age groups showed substantial declines in performance.

Although the figure has age on the abscissa, the groups were constituted by dates of birth. The youngest birth cohort was born between 1925 and 1932 with a mean age of 32 at the time of first performance. The next youngest was born between 1917 and 1924, and so on with the oldest cohort born between 1885 and 1892 with a mean age of 73 when first measured. Why did we use date of birth rather than age to categorize the groups?

During the period from mid-1964 to mid-1968, a subject-paced procedure was used for verbal learning. In mid-1968, the paced conditions were resumed. Those subjects measured between 1968 and 1974 who were born during the same birth periods as the initial cross-sectional sample were grouped according to birth cohort. This provided comparisons of independent samples of men born during the same period but measured at different times. As you now know, our sampling was far from ideal, and therefore such comparisons would not stand alone for these data; but we reasoned as follows. If the differences between independent samples from the same birth cohort were similar to the age changes in the conventional longitudinal comparisons, then we have additional supportive evidence for such age changes.

Let's look at the figure (Figure 1) again. Each solid line connects a pair of circles representing the two independent samples within a birth cohort but measured at different times. The sample measured in the early 60s was younger than the sample measured between 1968 and 1974. The solid lines show that for the late birth cohorts (the youngest), the age differences within cohorts were small, but for the groups born prior to 1900, within each birth cohort the mean number of errors for the younger group was smaller than for the older group. These data are consistent with the age changes based on repeated-measures of the same subjects.

Now let's look at the paired-associate data at the longer interval, the slower pace at which the subjects had more time to respond to each stimulus (Figure 2). As in the first slide, the cross-sectional data are shown by open circles. Age differences were small and apparent only for the two oldest groups.

The age changes for the longitudinal data again are shown by solid triangles connected by dashed lines. These data show age changes for all the groups, but again the oldest groups increased their errors the most.

The comparisons between independent samples from the same birth cohorts measured at different times are shown as before by circles connected by solid lines. With the exception of one of the younger cohorts, just as before the largest increases in mean errors were found for the earliest born cohorts (the oldest groups). Again the comparisons of independent samples from the same cohort provide supportive evidence for the longitudinal age changes among the oldest groups.

I should mention that for both pace conditions, WAIS Vocabulary means did not change even for the oldest cohorts with mean changes in learning. Furthermore, WAIS Vocabulary means were similar for independent samples born at the same time but measured at different ages; this was true even for the oldest cohorts who showed mean age differences in learning.

Now I will describe the serial learning study. Like the paired-associate procedure, the anticipation interval was varied; some subjects had 3.8 seconds to respond before the correct word was displayed, and the other subjects had 5.6 seconds to respond to each item. Each word was in view for 2.0 seconds for all subjects. The men assigned to the short interval for paired-associate learning were also assigned to the short interval for serial learning. Each list consisted of 12 highly familiar five-letter words such as RIVER. The dependent measure was the total number of errors until one errorless trial or for 48 trials.

Let's look at the slide (Figure 3) for serial learning at the short anticipation interval, the fast pace when the subjects had to respond more quickly. Just as in the previous slides, the cross-sectional data are shown with open circles connected by dotted lines. We can see that the young groups showed small age differences, but the oldest groups showed large age differences.

The conventional longitudinal data are shown with filled triangles connected by dashed lines. Mean errors for those men who returned and for whom a second valid measure was obtained are shown at first and second measurement. As you can see, the four youngest groups improved; mean errors declined. We have some independent data which showed that the second list was easier than the first despite their formal similarity. Nevertheless, mean errors increased for the two oldest groups despite the difference in list difficulty. So the pattern is similar to the paired-associate data; the oldest groups showed the largest declines.

The comparisons of independent samples from the same birth cohort are not affected by the list differences. Everyone learns the same list. These comparisons are shown on the slide as two circles connected by a solid line. For the birth cohorts born late (the youngest groups), mean errors for the samples measured in 1968 or later were not larger than for the comparable samples measured between 1960 and 1964. However, for the two birth cohorts born early (the oldest groups), the sample measured later had higher mean errors than the sample measured early. In other words, the sample that was older when measured made more errors than the younger sample who were born during the same period. Again some additional support for the longitudinal age changes in the oldest groups was found from the age differences between independent samples.

The next slide (Figure 4) shows the serial-learning data at the long anticipation interval, the slower pace. Just as before, the cross-sectional data from the early sample are shown with open circles connected by a dotted line. Like the paired-associate cross-sectional results at the slow pace, age differences were apparent but not large.

The longitudinal measures of age changes are shown with pairs of filled triangles connected by dashed lines. Again partially due to the easier second list, the youngest groups showed little change, but the oldest group increased their mean errors substantially despite the easier second list.

The comparisons between independent samples born during the same period were unaffected by list differences because everyone learned the same list. All of these comparisons within birth cohorts showed age differences favoring the younger sample, but the earliest born cohort (the oldest group) showed the largest age difference between the sample measured early (and therefore younger) and the sample measured later (and therefore older). As with the other data, these age differences support the age changes for the oldest groups in the longitudinal comparisons.

Again the WAIS Vocabulary means changed very little even for the oldest groups with mean declines in learning. And the Vocabulary means were similar for the independent samples within cohorts even for the oldest cohorts with mean differences in learning.

Now let's take a look at the memory-for-designs data. One of the reasons for selecting this task was to broaden the scope of cognitive measures to include a non-verbal memory task. This was not fully achieved, however. The Benton Visual Retention Test, which had been shown to be age related, includes many geometric figures which can be encoded verbally. For example, most of the designs in each form include a minor, peripheral geometric figure which is always a square, a circle, or an equilateral :iangle. Many of the major figures also are familiar geometric figures with names which lend themselves readily to verbal encoding, especially by educated subjects. Nevertheless, the Benton test of memory for designs was introduced into the Baltimore Longitudinal Study in 1960 at the same time as the two verbal-learning tasks.

Each form of the Benton consists of ten designs. Each design is displayed for 10 seconds and the subject's task is to reproduce the design from memory. He is given as much time as he needs to draw the figures. The measure we use is the total number of errors in all 10 designs. Despite the subjective element involved in scoring, inter-rater agreement is extremely high.

Let's look at the data (Figure 5). Just as in the other figures, the cross-sectional means for the early sample appear as open circles connected by dotted lines. There was a general increase in errors with the largest age differences among the oldest ages.

The longitudinal data are remarkably similar to the cross-sectional results. If we look at the dashed lines, each birth cohort showed an increase in mean errors from the first to the second measure; and the largest age changes were found among the oldest groups.

Similar results occurred for the comparisons of independent samples from the same cohort. If we look at the solid lines, we see that for each cohort, the sample measured later had a higher error mean than the sample measured early. In other words, within cohorts, the older men made more errors than the younger men born at the same time. And the largest differences were found among the oldest groups. The results of the independent samples comparisons support the evidence of substantial age changes late in life.

I would like to close by saying we are currently collecting third point data for these measures. Furthermore, we have much data about the health and physiology of these men. Those data hopefully will be a rich source of information. Why does the performance of some men decline and others not? This is a convenient point to emphasize that we have been talking exclusively about means. In every group, however, even the oldest, we find some men whose performance did not decline. The more we know about changes in other important variables, the more likely we will be able to answer questions about why some subjects decline and others do not. It should be noted that individual changes in performance and in other variables can be determined only when we have repeated measures for the same subjects. Although there are advantages to estimating change from independent samples from the same birth cohort, that approach cannot identify changes in individuals.

In general, these data indicate that verbal learning and memory-for-designs decline late in life. These findings, together with the results of our longitudinal problem-solving studies indicating declines in reasoning late in life, are not consistent with the "myth of intellectual decline."

Perhaps a word of caution would be helpful at this point. My emphasis has been on declines in performance late in life, but I do not mean to convey a message of doom. It is extremely important that we not return to the thinking so prevalent ten years ago that cognitive decline begins early in adulthood, is inevitable, and occurs in virtually every person in virtually every function culminating in substantial mental impairment.

Dr. Schaie and others have shown that several aspects of psychometric performance do not decline throughout life. Even when they do decline late in life, the changes are typically small and probably are not important in the problems of every day living.

On the other hand, I am concerned that the pendulum has swung to the other extreme. If professionals and scientists in aging believe that cognitive performance does not decline in any way (except speed), then it would be easy to think that the search for mechanisms and solutions to the problem are unnecessary. Our findings indicate that, for several types of cognitive performance, decline is the norm even in an educated, relatively healthy sample. It seems clear, therefore, that we have our work cut out for us.

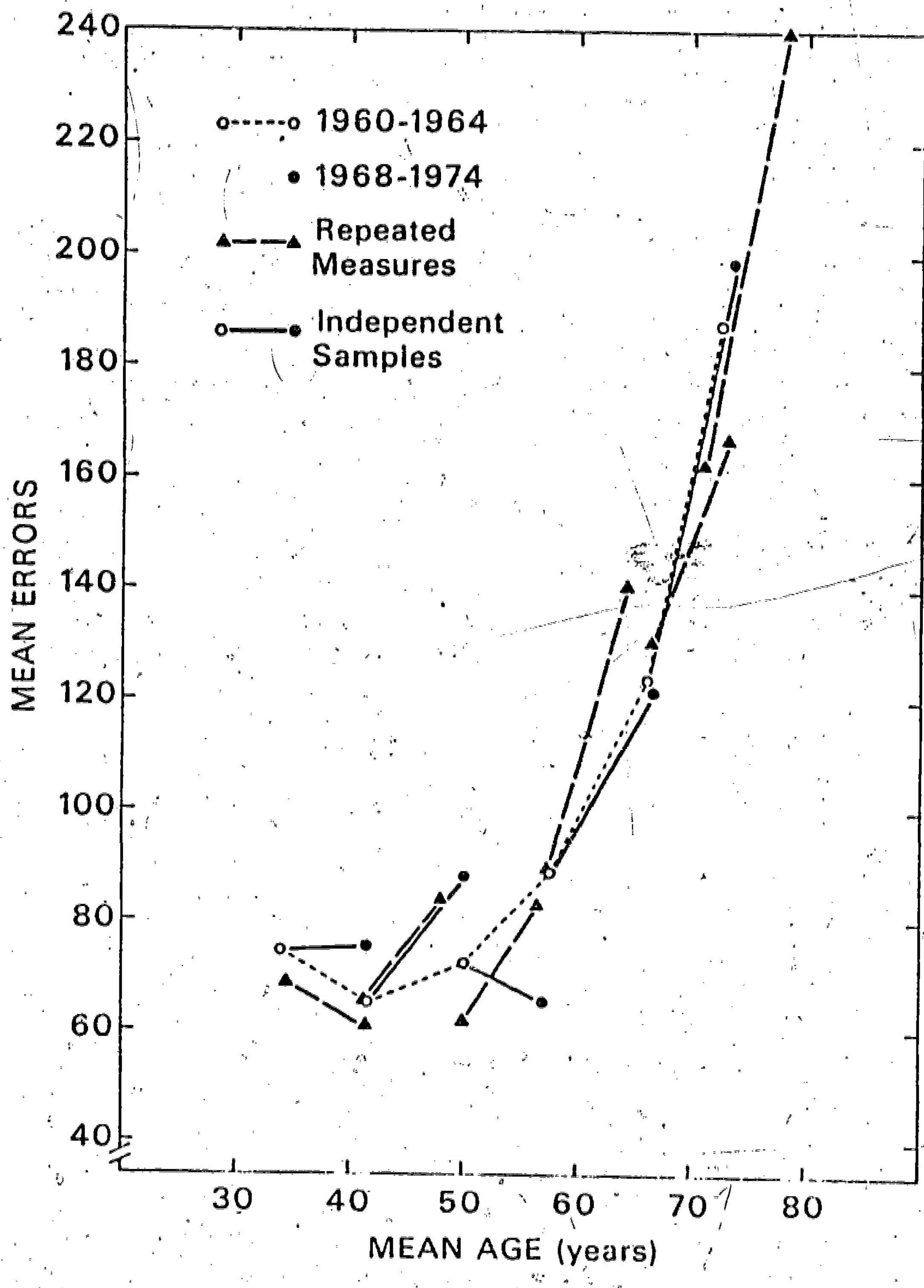

Fig. 1 Paired-associate learning -- short interval

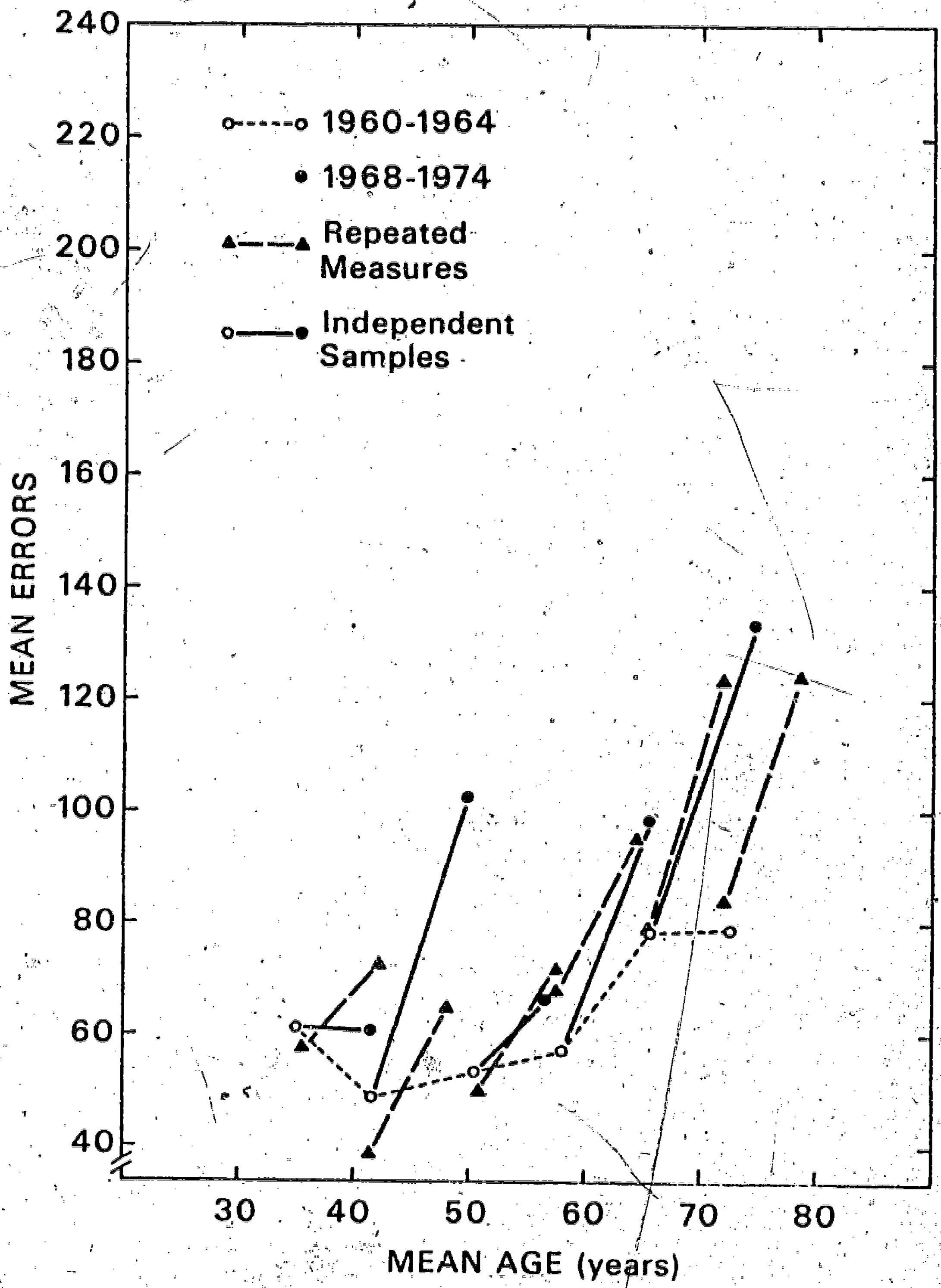

Fig. 2 Paired-associate learning -- long interval

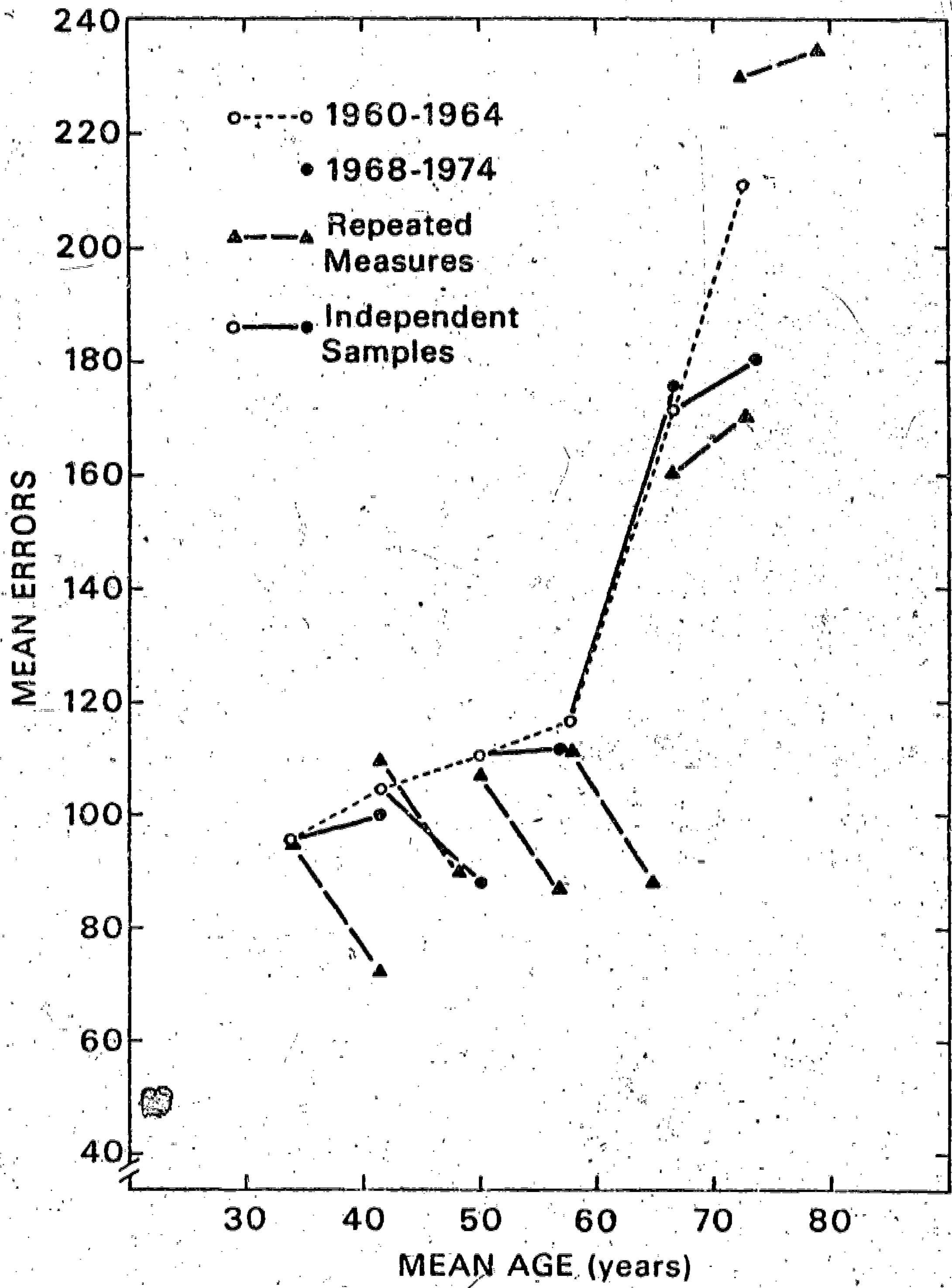

Fig. 3 Serial learning -- short interval

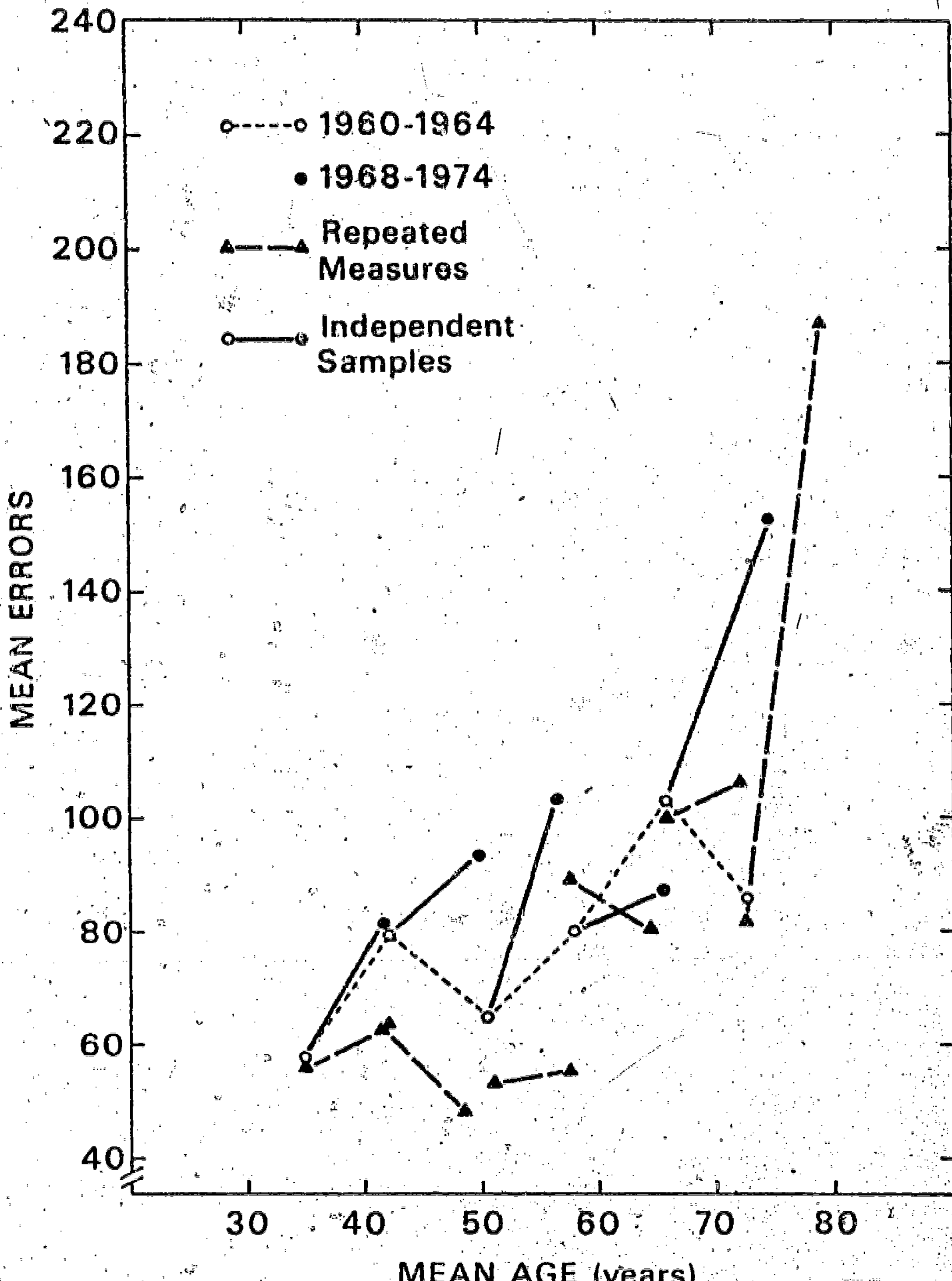

Fig. 4 Serial learning -- long interval

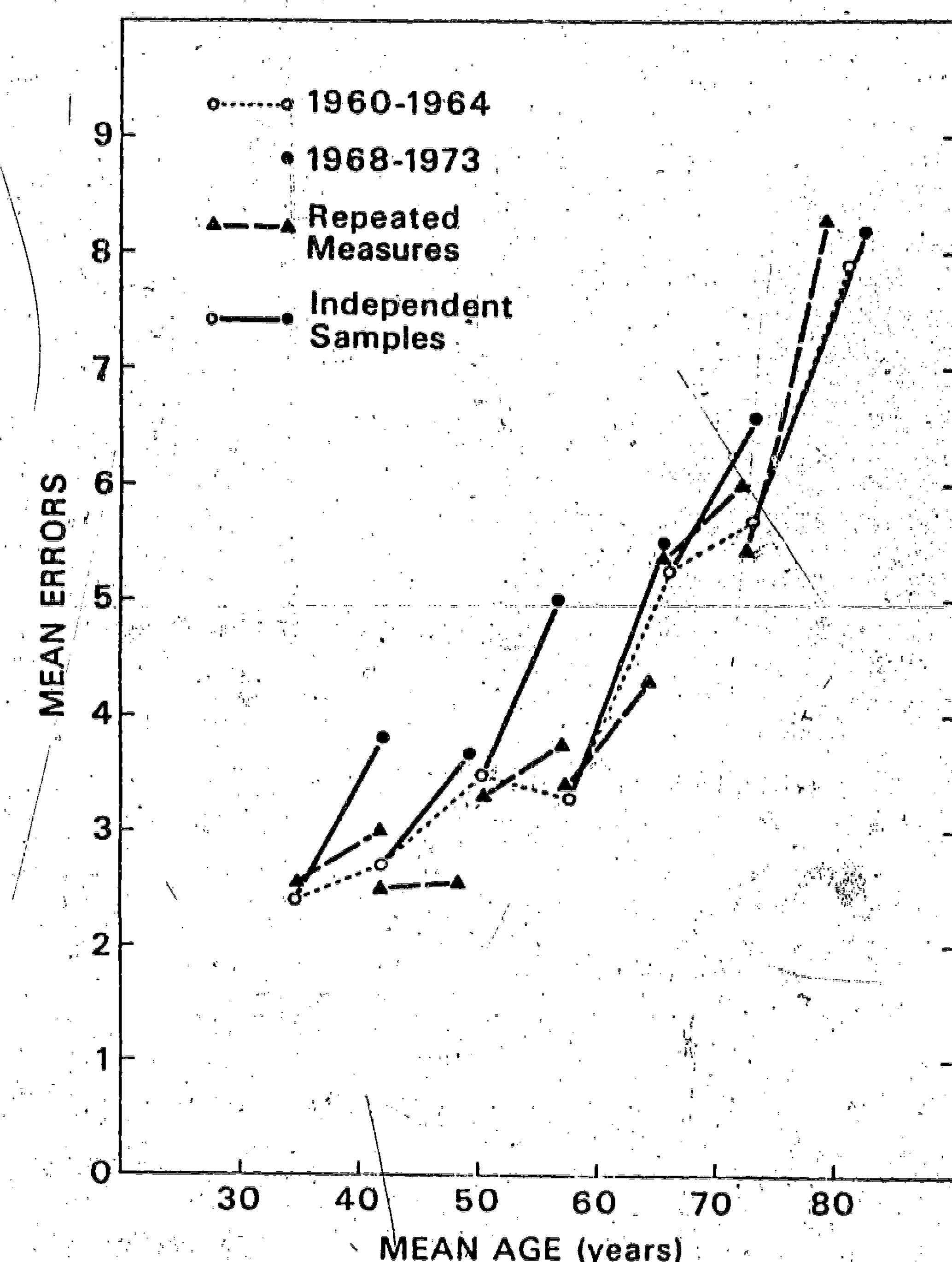

Fig. 5 Benton Visual Retention Test