Psychological Limitations That Occur With Age

By JAMES E. BIRREN, Ph.D.

THE PURPOSE of this paper is to describe a few limitations that may occur with age and to draw some preliminary inferences about the underlying mechanisms. The scientific literature on the psychological aspects of aging is increasing. The contributions from the Cambridge Laboratory in England (*1–4*) and the publications of numerous investigators in this country have given us many facts to digest. Recently, reviews have appeared on special aspects of aging, such as psychomotor changes, changes in mental abilities, and changes in personality (*5–7*). Many summaries of the literature were presented at the Bethesda Research Conference on the Psychological Aspects of Aging (*8*). With this factual background in mind, it is proper that we begin to consider some of the general mechanisms which may underlie the psychological limitations of aging.

It is implicitly assumed that from considerations of basic facts and information suggestions will become apparent for the prophylaxis and alleviation of many of the limitations which occur with age. Because we use the term "limitations of aging," it should not be assumed that aging is inevitably linked with limitations. The advantages associated with advancing age, like those of growth, take care of themselves, but limitations and defects do not. To these we must direct the knowledge of our sciences and professions if we are to increase the number of healthy, happy, informed, and independent older persons.

Dr. Birren is chief of the Section on Aging, Laboratory of Psychology, National Institute of Mental Health, Public Health Service, Bethesda, Md.

A Point of View

There are two psychologies to be considered in relation to limitations of aging. One is clinical and is concerned with diagnostic, therapeutic, rehabilitative, and supportive procedures. The other is directly concerned with research or experimentation on mechanisms of aging. The point of view adopted in this paper is that of research. We are seeking explanatory principles that might begin to link the now disparate facts about aging.

Generalization vs. Individual Differences

For many psychological and biological processes, about 50 percent of the variation in the data is explained by the general age trend. Thus, in many studies, the range of individual differences is about equal to the magnitude of the mean trend. Whether we emphasize the general trend in our psychological or biological data or the range of individual differences depends upon our purposes. The clinician is more often interested in the uniqueness of the individual under study than in the general characteristics he shares with other people. The biologically minded psychologist is more often concerned with an analysis of the general characteristics. Both the general trend and the range of individual differences are proper subjects for study.

An Emerging View

As individuals, we are continually concerned with an emerging point of view toward human aging, that is, the proper combination of generalizations with specific facts from personal experience. At some point the experimenter joins with the clinician and with informed people in general to give an appropriate weighting or perspective to the facts of psychological limitations in aging. But what facts should be emphasized? Should we emphasize that there appears to be a disparity between the observable anatomical changes of aging of the nervous system and the changes seen in individual behavior and personality? If this is emphasized, we encourage acceptance of or complacency about our lack of knowledge concerning the relations between psychological functions and the structures of the nervous system. It does not appear to be sound mental health to encourage the idea that successful aging is entirely a voluntary phenomenon and that all older people are capable of doing outstanding things if they would only try. The mature point of view toward human aging seems to represent a balance between optimism and realism and an avoidance both of excess voluntarism and of undue stress on the limitations of aging.

Speed in Timing in Human Behavior

Perhaps the most significant result of research on age changes in the nervous system in the past 10 years is the implication that there is a general slowing of all voluntary responses. In a previous review it was pointed out not only that the slowing of voluntary responses with age is an overt manifestation but also that there is evidence of slowing of covert responses in aging, such as speed of associations of thought (*9*). The change in response latency appears to be our most fruitful point of departure for exploring the nature of age changes in behavior and perhaps for the significance of the age changes in the structures of the nervous system.

In young adults individual differences in speed seem to have only limited psychological importance. In aging, however, individual differences in speed or response latencies seem to be an important independent variable for the psychologist to consider. Recent research suggests that the time delay between stimulation and response is primarily a property of the central nervous system, whereas earlier research tended to minimize the importance of time differences that might be observed in simple and choice reaction time measurements. The slowing with age has to some extent been viewed as an arbitrary or artifactual aspect of performance of the older person. Implicit in such a view is the assumption that the slowing occurs only in the response or output mechanisms and is unrelated to the speed or the quality of events preceding the initiation of response. Were the loss of speed with age a peripheral phenomenon, it would of course be of limited psychological interest.

Simple speed tests seem to differentiate more clearly between senile psychotic individuals and control subjects than do various combinations of rather complex mental tasks. For example, a 2-minute writing test was found to differentiate senile patients and control subjects (*10*). In contrast, a 1½-hour psychometric test designed to measure deterioration did not yield such differentiation. Again, later studies showed that this difference was not simply a peripheral limitation on the writing speed, but that the speed of writing was correlated with the probability of the antecedent events being correct (*11*).

What requires the additional time in the older nervous system? Does a timelag occur in the retina or in the optic nerve? Is there an increased latency in the primary sensory projection area of the brain or in an association area? Is additional time required in programing appropriate motor responses in the motor cortex or in the spinal cord? Does the peripheral nerve or the myoneural junction require more time in its functions?

It was originally thought that older people adopted a slow tempo of response. Hence the increased latencies of voluntary responses were not viewed as a reflection of reduced capacities of the nervous system but phenomena of attitude or set. It has now been shown that at least in one other species, the rat, a slowing of response latency occurs with age. In a recently published study of startle responses of rats of different ages, it was shown that for older rats there is an increase in response time to electric shock and to sudden noises (*12*). Furthermore, when attempts were made to decrease the response time of these animals by increasing the electric shock, a minimum reaction time was reached beyond which a further increase in the stimulus strength did not result in a further reduction in reaction time. At this plateau, or asymptotic level, of response, there was a residual difference between young and old animals.

An experimental attempt was also made to see to what extent the slowing with age could be related to conduction velocity of peripheral nerve in the rat. In this study the conduction velocity was measured in isolated sciatic nerve excised from more than 75 rats ranging in age from 50 to 850 days (*13*). Conduction velocity increased during development, but it did not change significantly after about 300 days. The results of that study taken together with results of previously reported studies indicate that changes in peripheral nerve do not appear to be important in the changes which we see in such functions as simple reaction time in later life (*9*, *14*).

Recent and unpublished studies by Dr. Alfred Weiss of the National Institute of Mental Health and by Dr. Botwinick, also with the institute, and myself have found no evidence as yet that the age changes in the speed of human voluntary response to any large extent lie in either the receptor or in the effector processes. An earlier study by Johannes Sommer indicates that the age change in a simple spinal reflex in the human is small; it seems to be of the order of perhaps 1 millisecond compared with the 50 or more milliseconds that differentiate the voluntary responses of a young and an older person (*9*).

The recent work of Kumnick on pupillary responses to light indicates that under some circumstances the latency is unchanged with age. This implies that at least under some conditions the rapidity of all the events, from the stimulation of the receptors in the eye to the effecting of pupillary constriction, must be unchanged with age. Apparently, the older pupil constricts at a normal rate in proportion to its smaller size. Since the older pupil is usually somewhat smaller, it may, however, give the illusion of a slower response. If this rather complicated reflex remains unchanged in later life, we might speculate that some of the purely sensory components are also unchanged in relation to latency of perception and the initiation of voluntary responses.

Apparently, the decrease in speed of voluntary responses with age is primarily a phenomenon of the central nervous system and conscious behavior. This provokes a dilemma because the physiological methods which might be appropriate to a study of the phenomenon are ones which are so artificial (for example, anesthetizing the organism) that they preclude studying manifestations in the conscious state. The problems lie in an experimental area wherein the relevant types of experimentation and variables are familiar to the experimental psychologist, and the inferences lie in the domain of the neurophysiologist.

A depressed person might respond slowly and yet retain a capacity to respond quickly, whereas it is extremely doubtful that the older organism maintains the capacity for rapid response. Responses of the elderly are made at some uniformly slow rate (*15*). This suggests that we might speak of less "temporal modulation" of voluntary responses. Implications of this concept are important in attempts to define the environment wherein the older person would be most comfortable. In general, the older person is most comfortable in a situation in which he can pace his responses and is least comfortable in one in which he must respond quickly to demanding sequential stimuli. Rapid sequential stimuli occur, for example, in automobile driving. This situation is not revealed satisfactorily by an analogy to a simple reaction-time experiment. Recent findings in our laboratory show that there is a difference in readiness to respond in the elderly as compared with the young. Different age curves were obtained for changes in response time as a function of preparation. It is not possible to say at this time whether the lower level of response readiness or expectancy is independent of the increased latency or is a different manifestation of a common underlying change in the character of nervous system functioning. Also, we do not yet know whether complex tasks merely show a multiplicative effect of the longer latencies. Again it may be that the same basic process is simply disproportionately represented in a complex situation.

Serial Movements in Timing

There is evidence that one of the limitations older persons face is difficulty in timing sequential events. Kay pointed out that his learning experiments suggest that with advanced age some individuals display a difficulty in "programing" sequential movements (*1*). This was noted also in earlier work on age changes in handwriting. In some aged individuals handwriting tends to become a series of discrete movements, instead of a smooth, overlapping of movements, that is, it becomes more like drawing. This is analogous perhaps to a change in a feedback mechanism wherein the older organism is unable to use the information obtained from the execution of a preceding movement to modify a following one or is unable to do so with sufficient speed. Singleton pointed out that the speed of movements, once the movements are initiated, is unchanged in older persons. What requires additional time with age is the decision points in movements (*2*).

For optimum skill, the proper moment for initiating responses must be anticipated. Components of serial responses must be programed in advance to conserve time. If the response components are not anticipated or programed they appear as discrete events separated by delay intervals. A slowness in developing or programing future responses may limit the aged in the execution of some highly complicated skills, the essence of which is the flowing of activities or movements one into the other. It is perhaps highly relevant to note that, when a skill is first acquired, the component movements appear discrete and that, as the skill is improved, these movements are gradually combined into a continuous pattern. As a skill deteriorates, it may again assume the quality of separate movements. Timing seems to have a perceptual character, that is, one sees or feels the right moment to make a response. Difficult conditions exist when the signals come close together.

In the preceding remarks, the facilitation of voluntary response was emphasized. However, in the aging nervous system there may exist a general change in excitability which would be reflected in both facilitatory and inhibitory functions of the nervous system. Perhaps more common in daily life than a demand response to a stimulus is the situation in which the stimulus may be anticipated and received in advance of the appropriate moment for the response. Good timing may thus be more a matter of inhibiting the response until the proper moment than a matter of its facilitation. In aging there may exist a narrowing of the range between minimum response time and maximum response time. This topic requires more information than now exists about the length of delays which can be interpolated between sequential stimuli without the behaviors disintegrating or being forgotten.

Viewed from one aspect, the nervous system appears to be more determinate in the aged than in younger persons, that is, the output tends to be more directly a function of the input. There is, of course, a tendency to cultivate certain types of determinacy or redundancy, as in the social graces. It is of interest to note that the social facade may be the last bit of behavior to disintegrate in the senile individual. Our psychological data on aging should be sifted for influences of our cultural pattern that determine which areas of our behavior may be novel and which are expected to be predictable.

Perceptual Difficulty

Perceptual difficulty, or inability to perceive information in order to achieve an appropriate response, may contribute to the age changes in behavior. One experiment attempted to see to what extent the response time of old and young people would vary as a function of perceptual difficulty (*16*). Young and elderly subjects were required to judge which of two simultaneously presented lines was the shorter. The lines were presented tachistoscopically. Each subject made a minimum of 48 judgments in a series of line pairs which differed in length from 1 to 50 percent. The subject was required to respond as quickly as he could when the lines were presented by saying "right" or "left" to indicate the side of the shorter line. The vocal response of the subject interrupted a chromoscope circuit, and his response time was measured to the nearest one-hundredth of a second. A significant difference in response time between the two age groups was found at all levels of difficulty of judgment. The response time of the elderly was relatively longer, however, when the stimulus difficulty was increased. Thus, the difference in response time between the young and the elderly subjects was 0.47 seconds at a 1 percent difference in line length, whereas for a 50 percent difference in line length the response time of the young and older subjects differed by 0.18 seconds. It is apparent that perceptual difficulty can contribute to the slower response of elderly subjects. However, there is a residual age difference in response time which exists regardless of the ease of the perceptual task involved.

Again, one might question whether a large part of this difference in response latency is not due simply to the difference in speed of vocalization. For this reason we conducted another experiment in which we studied age differences in finger, jaw, and foot reaction time to auditory stimuli (*14*). The hypothesis was that, if a general factor were underlying the age change in response latency, we would get a constant increment in reaction time with the jaw, finger, and foot. If the age changes were primarily involved in the peripheral pathways, then the reaction time with the foot with its long pathways might be disproportionately slow as compared with the finger or jaw. In this study, the reaction time of the elderly subjects was significantly slower than that of the young subjects for the finger, jaw, and foot, but there was no relation to the length of the peripheral path involved. Since the age differences between the reaction-time means did not change significantly in comparing the finger, foot, and jaw, it may be concluded that the age change in reaction time is not a variable associated with the length of the peripheral path. Collectively, the evidence suggests that it is plausible to regard the age change in response latency as a general property of the central nervous system.

Summary

For many psychological and biological processes there is a general age trend which in some instances explains about 50 percent of the variation in the data. There is an equally large range of individual differences. It depends upon our purposes whether we study and emphasize the general age trend or the individual differences in aging. Both the general age trend and individual differences are important.

Perhaps the most significant result of research on age changes in the nervous system is the implication that there is a generalized slowing of all voluntary responses. On the whole, the evidence indicates there are grounds for regarding the age change in response latency as a general property of the central nervous system. The longer response latencies appear to have their greatest consequence for complex or serial activities. The facts offer suggestions for further research into the bases of the changes, as well as for structuring the environment in order to reduce problems of living due to the psychological limitations of aging.

REFERENCES

(*1*) Kay, H.: Some experiments on adult learning. *In* Old age in the modern world. London, E. and S. Livingstone, 1955, pp. 259–267.

(*2*) Singleton, W. T.: Age and performance timing on simple skills. *In* Old age in the modern world. London, E. and S. Livingtone, 1955, pp. 221–231.

(*3*) Szafran, J.: Experiments on the greater use of vision by older adults. *In* Old age in the modern world. London, E. and S. Livingstone, 1955, pp. 231–235.

(*4*) Welford, A. T.: Skill and age. London, Oxford University Press, 1951, p. 161.

(*5*) Birren, J. E.: Age changes in mental abilities. J. Business 27: 156–163 (1954).

(*6*) Jones, H. E., and Kaplan, O. J.: Psychological aspects of mental disorders in later life. *In* Mental disorders in later life, edited by O. J. Kaplan. Stanford University, Calif., Stanford University Press, 1945, pp. 69–115.

(*7*) Kleemeier, R. W.: Age changes in psychomotor capacity and productivity. J. Business 27: 146–155 (1954).

(*8*) Anderson, J. E., Editor: Proceedings, Research Conference on the Psychological Aspects of Aging. Washington, D. C., American Psychological Association, 1956, 320 pp.

(*9*) Birren, J. E.: Age changes in speed of simple responses and perception and their significance for complex behavior. *In* Old age in the modern world. London, E. and S. Livingstone, 1955, pp. 235–247.

(*10*) Birren, J. E., and Botwinick, J.: The relation of writing speed to age and to the senile psychoses. J. Consult. Psychol. 15: 243–249 (1951).

(*11*) Birren, J. E., Allen, W. R., and Landau, H. G.: The relation of problem length in simple addition to time required, probability of success and age. J. Gerontol. 9: 150–161 (1954).

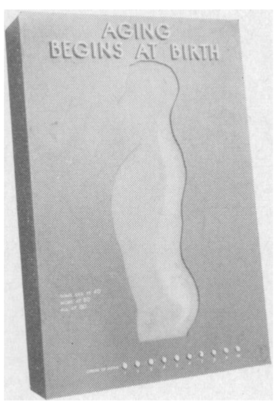
(*12*) Birren, J. E.: Age differences in startle reaction time of the rat to noise and electric shock. J. Gerontol. 10: 438–440 (1955).

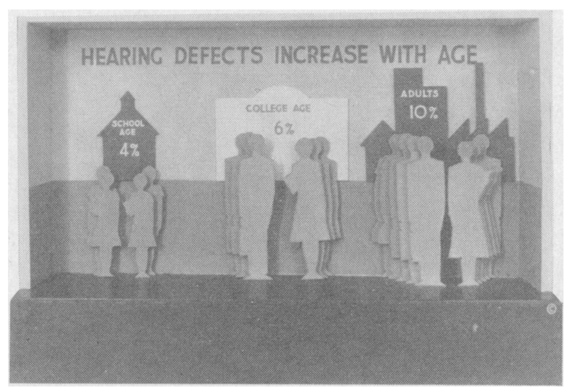
(*13*) Birren, J. E., and Wall, P. D.: Age changes in conduction velocity, refractory period, number of fibers, connective tissue space and blood vessels in sciatic nerve of rats. J. Comp. Neurol. 104: 1–16 (1956).

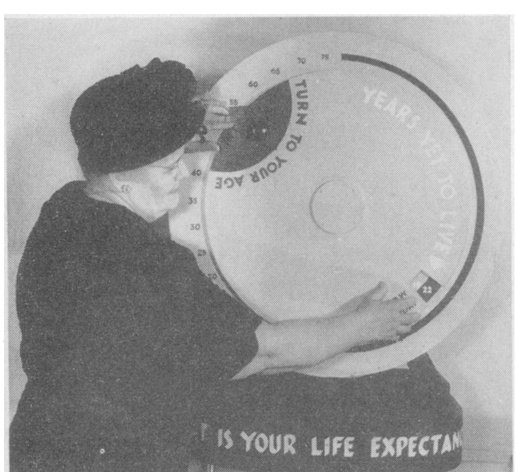
(*14*) Birren, J. E., and Botwinick, J.: Age differences in finger, jaw and foot reactions to auditory stimuli. J. Gerontol. 10: 430–432 (1955).

(*15*) Botwinick, J., and Shock, N. W.: Age differences in performance decrement with continuous work. J. Gerontol. 7: 41–46 (1952).

(*16*) Birren, J. E., and Botwinick, J.: Speed of response as a function of perceptual difficulty and age. J. Gerontol. 10: 434–436 (1955).







Making Health Visible

Among the exhibits and other educational materials offered by the Cleveland Health Museum in its catalog, "How to Make Health Visible," three illustrated on this page are among those which particularly concern the subject of age. One is a device which permits visitors to learn the average life expectancy, according to present mortality tables, for their age and sex. Another illustrates the point that aging begins with mitosis. The third illustrates the gain in hearing deficiencies with advancing years.