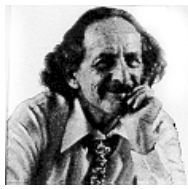
Essays of an Information Scientist, Vol:7, p.97-107, 1984
Current Contents, #14, p.3-13, April 2, 1984

Current Comments®



Social Gerontology. Part 1. Aging and Intelligence

Number 14 April 2, 1984

A previous essay discussed the biology of prolongevity, including genetic, cellular, immunological, neuroendocrine, and free radical theories on aging.[1] That essay also addressed the question of why aging evolved and what purpose it serves. At that time, I noted that the social and economic consequences of a major breakthrough in aging research would be tremendous.

Many of the theories discussed in the prolongevity essay are fairly speculative. Also speculative are estimates of the effects a much longer life span—say, 110 years—might have on society. What is known, however, is that the number of US citizens over 65 grew fourfold during the first half of this century.[2] And this growth is already placing considerable demands on our social and political institutions.

This two-part essay on social gerontology examines the sociological and psychological aspects of aging. There is a considerable literature on this topic, so we can only highlight two aspects of this field in these essays. Perhaps we will be able to extend our coverage of social gerontology in the future. This week the effects of aging on intelligence, memory, and learning will be reviewed. In a future essay, some of the effects of having a larger proportion of aged people in the population will be discussed. At that time, we will also discuss some of the steps individual nations are taking to cope with growing elderly populations.

During various periods in history, and among different societies, attitudes toward the elderly and the process of aging have differed considerably. The fifth-century BC Greek historian Herodotus reported that the Issedonians gilded the heads of their elderly and offered sacrifices to them.[3] The people of Bactria, in contrast, fed their elderly to flesh-eating dogs.[4] And the ancient Sardinians hurled their elders from a high cliff and shouted with laughter as they fell on the rocks.[5]

Today, we outwardly treat our elderly with more respect than did the Bactrians or Sardinians. But we've also moved precariously far from the reverence of the Issedonians. This is confirmed by attitude studies carried out in the US in the past three decades.[6-9] These studies reveal that many people view the elderly as predominantly sick, tired individuals who are often grouchy, withdrawn, and self-pitying. According to this stereotype, older people are mentally slow, have trouble learning and remembering, and have little or no interest in sex.[6] Robert N. Butler, the founding director of the National Institute on Aging (NIA) who is now at Mount Sinai Hospital, New York, refers to this stereotyping, and the discrimination that accompanies it, as "ageism." He likens ageism to racism and sexism, noting that it allows young people to "cease to identify with their elders as human beings."[10] (p. ix)

Why has ageism come about? There are a number of reasons, not the least of them being our own fears about growing old. This fear, no doubt, has prompted much of the prolongevity research men-

tioned earlier.[1] But social gerontologists—sociologists, psychologists, economists, and others who study aging—offer a number of other explanations as well. Robert F. Almeder, Georgia State University, Atlanta, attributes ageism to materialism. Almeder notes that in a materialistic society, where people are judged according to their productivity and wealth, it is not surprising to find that "the elderly lose their right to respect" as they abandon their economically productive role.[11]

Donald O. Cowgill, University of Missouri, Columbia, claims that "modernization" has lowered the status of aged individuals. Cowgill reports that the elderly tend to be revered in the more primitive societies where they're relatively rare, and where their experience can benefit younger people. As a society modernizes, technological advances increase the proportion of aged individuals while making their talents obsolete.[12]

One of the most harmful outcomes of this obsolescence may be that it reinforces the stereotype that the elderly are less intelligent than the young. Such stereotypes, particularly regarding elderly people's supposed inflexibility and inability to learn new things, can cause job-related discrimination.[13,14]

Until recently, many researchers agreed that certain intellectual skills decline with age. Now, according to Matilda White Riley, NIA, they are finding that intellectual decline is not inevitable. Riley notes that much of the age-related decline observed in earlier studies may have actually been the result of poor health or the use of medications that impair intellectual functioning. A lack of intellectual and social stimulation, and an absence of opportunities and incentives for cognitive functioning, are also coming to be recognized as causes for the decline observed among some elderly people.[15] Granted, declines may be found in some individuals, but these declines appear to be so minor that they have almost no effect on the daily lives of physically and mentally healthy older adults. Moreover, those declines that do occur are not irreversible.[16]

Since intelligence involves such diverse skills as problem-solving, reasoning, and numerical facility, researchers have developed classification systems to describe various types of intelligence.[17] John L. Horn, University of Denver, Colorado, and Raymond B. Cattell, working at University of Hawaii, Honolulu, and University of Illinois, Urbana, described two general forms of intelligence that are now widely used in the gerontological literature.[18-20] *Crystallized* intelligence is somewhat like knowledge. It results from education, experience, and acculturation and is measured with tests of verbal comprehension, vocabulary, and numerical skill. *Fluid* intelligence represents the ability to solve new problems, reason abstractly, and adjust one's thinking to unfamiliar situations. Fluid intelligence appears to be influenced by one's physiological and neurological health. It is measured through performance tests that involve solving new types of problems and using perceptual motor skills.

In numerous studies done in the past three decades, fluid intelligence was found to peak and decline earlier than crystallized intelligence. Consequently, elderly individuals tended to score higher on tests of crystallized intelligence. However, for healthy people the decline in fluid intelligence does not have any practical effect until their mid-70s or early 80s. At this point, gains in crystallized intelligence also become smaller.[21]

Despite the large amount of research that has been done on aging and intelligence, researchers continue to debate whether an age-related decline occurs in healthy individuals, as well as the extent of this decline. During the mid-1970s, in fact, a well-known debate over age and intelligence took place, most notably in

the pages of *American Psychologist*. Briefly, K. Warner Schaie, working at the University of Southern California, Los Angeles, and Paul B. Baltes, working at Pennsylvania State University, University Park, took the position that a decline in intelligence was not inevitable with age.[22,23] In contrast, Horn and Gary Donaldson, University of Denver, argued that a substantial decline in fluid intelligence does occur.[24,25] Much of this controversy has, in the past, centered on the different results reported with different study designs.

The earliest studies of aging were cross-sectional—different age groups were compared at a single point in time. In these studies, researchers found small but significant differences with age, particularly in fluid intelligence, beginning in late adolescence. Horn reports that these range from three to seven intelligence quotient (IQ) points per decade from ages 30 to 70.[26] But later longitudinal studies, which measured changes among the same group of people over time, suggested that these changes began later in life.[27] They indicated that at least some of the decrement noted in cross-sectional studies was caused by the lower educational levels of the older groups, or cohorts, in these studies. Furthermore, the tests used in these studies were designed for college students and others seeking entry-level jobs.[16] So they may not have measured cognitive processes that are more critical later in life, such as decision-making and other tasks that make use of accumulated experience.[16]

While cross-sectional studies seemed to magnify age changes, longitudinal studies tended to minimize them. Jack Botwinick, Washington University, St. Louis, maintains that people who perform poorly on standardized tests tend to be less available for repeat testing than people who perform well.[28] Consequently, median scores in longitudinal studies are often spuriously high because they reflect the scores of the more able older people who agree to be retested. In reanalyzing data from one of the most comprehensive longitudinal studies of aging and intelligence,[29] Botwinick found median test scores actually increased with age due to selective dropout.[28] As less intelligent members of the group dropped out of the test sample, the brighter members brought the average score up.

In the 1950s, Schaie, Baltes, and colleagues began using a methodology that attempted to resolve the discrepancies between cross-sectional and longitudinal studies.[30-33] They used a "sequential analysis" design that incorporated both types of studies. The group initially tested in 1956 included individuals aged 22 to 67. The same group was retested every seven years until 1977. The cross-sectional analysis of test data showed a downward trend in test scores. But the longitudinal analysis showed a decrease on only one of the five dimensions of intelligence measured—the ability to shift from familiar to unfamiliar patterns in visual-motor tasks. Schaie and Christopher Hertzog, Pennsylvania State University, concluded that generational differences in intellectual performance resulted in "an overestimation of the magnitude and age of onset of intellectual decline."[32]

Schaie also found that scores on tests of crystallized intelligence improved for each successive generation. He suggested that each group performed better because its members were better educated. In an earlier study of the relationship between education and intelligence, James E. Birren, now at the University of Southern California, and D.F. Morrison, working at the National Institute of Mental Health, Bethesda, Maryland, found that education had an even greater effect on test scores than did occupation, which would seem more relevant to the maintenance of intellectual function among older people.[34]

Finally, Schaie also found wide variability in the performance of individuals 80 and older. He traced this variability to such factors as the different economic status, intellectual stimulation, and health of test subjects.[16]

While most researchers acknowledge at least some decline in fluid intelligence, the gerontological community has been split on the significance of this decline. On one side of the argument are investigators who believe that factors unrelated to intelligence cause older people to perform poorly on tests of fluid intelligence. Chief among these factors is the slower response of older people. This may cause them to take longer to evaluate and respond to test questions. This slowdown may make it more difficult for elderly persons to do well on fluid intelligence tests because these tests often require rapid responses. Two other important factors affect performance on these tests. The elderly are reluctant to take risks—they tend to sacrifice speed for accuracy. And the older person experiences high anxiety in unfamiliar testing situations.[35]

On the other side of this debate are researchers who argue that response speed is an integral component of intelligence. They maintain that the slower response is a normal part of aging. Therefore, declining scores on fluid intelligence tests reflect real intellectual decline.[28] Studies attempting to isolate response speed from intellectual competence have provided mixed results.[36-38]

Gerontologists have investigated the reasons for the slowdown in response. Although the precise physical causes still remain a mystery, by the mid-1960s, researchers such as Alfred D. Weiss,[39] Harvard Medical School, Cambridge, Massachusetts, and Botwinick and Larry W. Thompson,[40] working at Duke University Medical Center, Durham, North Carolina, had found that the slowdown affects the transmission and integration of information in the central nervous system (CNS). Robert C. Atchley, Miami University, Oxford, Ohio, explains that older people tend to make more errors on speed-based tests because "too little information can be processed between the time the sensory input is received and the time action must be taken."[41] (p. 48)

Also contributing to delayed response, but to a lesser extent than the slowdown in the CNS, is the fact that older people generally require more sensory stimulation before they are aroused. For example, a noise must be louder or last longer before an elderly person perceives it. A.T. Welford, University of Hawaii, Honolulu, attributes the higher sensory threshold to "anatomical deterioration of the sense organs" and, more importantly, to increased random activity in the CNS, also called "neural noise."[42] Sensory information must compete with this background neural noise to gain an individual's attention.

Some investigators believe that a "terminal drop," a decline in intelligence a few months or years before death, may explain lower test scores among the elderly. In a 1972 study examining the relationship between test performance and survival, Klaus F. and Ruth M. Riegel, working at the University of Michigan, Ann Arbor, found an individual's test score tended to drop markedly within five years before death.[43] Similarly, in an earlier study on this theme, R.W. Kleemeier, working at Moosehaven Research Laboratory, Orange Park, Florida, found that elderly subjects who died soonest after a test also tended to be those with the lowest scores.[44] A number of investigators suspect that some neurophysiological processes, probably related to dying, may cause a drop in intelligence. In the 1960s and 1970s, researchers suggested that this terminal drop, rather than aging *per se*, might be responsible for lower intelligence test scores among the people

who are oldest, and therefore closest to death.[28] Atchley notes that more recent research on this topic, while not entirely discrediting the terminal drop theory, has indicated that the drop may occur primarily in people with multiple chronic conditions, such as atherosclerosis and diabetes.[45]

Much of the most current research on aging and intelligence focuses on the effects of educational intervention. Studies by Baltes,[46] now at the Max Planck Institute for Human Development and Education, Berlin, by Schaie,[33] and by Sherry L. Willis,[47] Pennsylvania State University, indicate that training elderly people, or giving them an opportunity to use their minds, can improve their performance on intelligence tests appreciably. In a study in which elderly people received training in spatial orientation and inductive reasoning—skills in which most elderly people are likely to show declines—more than three-fourths of the subjects showed improvement which lasted at least six months.[46] Riley notes that many subjects raised their performance to the level they performed at some 20 years earlier.[16] Schaie was asked to comment on this intervention research. He observed, "The use-it-or-lose-it principle applies not only to the maintenance of muscular flexibility, but to the maintenance of a high level of intellectual performance as well."[21]

Riley[15] asserts that these educational intervention studies[33,46,47] are having an enormous impact on the gerontology community. So are other recent studies in which elderly people are provided with incentives to perform well on tests.[48] These studies are calling into question assumptions about intellectual decline by suggesting that environmental factors may far outweigh any age-related effects on intelligence. Also being reexamined in recent years is the validity of the tests administered to elderly people. As mentioned earlier, many of these tests are inappropriate for the elderly, because they may not be measuring the skills that become better developed and more useful with advanced age. Riley says that the NIA is beginning to examine more relevant components of intelligence "such as experience-based decision-making, interpersonal competence, or 'wisdom.' "[16] If methods for measuring these components can be found, they may be used in designing intelligence tests that will be "valid across the entire life course."[16] According to Riley, this recent work on motivation, test validity, and educational intervention is also calling into question earlier findings on the effects of reaction time on cognitive performance. She has found, "Even reaction time can be improved by giving people hints and cues on speeding up their performance."[15]

Closely related to the intellectual performance of elderly people—and to a large extent, underlying it—are age-related changes in learning and memory. For example, poor test performance could result from failure to learn the material adequately in the first place, to retain it in memory, or to retrieve it from memory within the time limit provided.[17] It is difficult to isolate memory loss from learning decrements, since you must learn material before you can remember it, and remember it to show you've learned it. But gerontologists generally agree that learning ability does decline with age, though not noticeably until past middle age. As with other intellectual skills, learning seems to be affected by a general slowdown in response. When given enough time to memorize or learn material, learning in the elderly improves considerably. Recent work by Michael Perone, University of North Carolina, Wilmington, and Alan Baron, University of Wisconsin, Milwaukee, has shown that training and practice can also improve learning ability, even under time constraints.[48]

Researchers have attributed age-related declines in learning to a number

of factors. These range from a lack of recent experience in learning situations to a lack of motivation to learn.[17] William J. Hoyer and Dana J. Plude, Syracuse University, New York, found that learning ability in the aged may be restricted by a decreased ability to distinguish relevant material from irrelevant material.[49] Carl Eisdorfer, Montefiore Hospital, Bronx, New York, found learning was also restricted by elderly people's anxiety in learning situations.[50,51] In a study in which he monitored the fatty acid levels of younger and older subjects to determine autonomic (involuntary) nervous system arousal during tests, Eisdorfer found that the nervous system in older persons became aroused as the test progressed.[50] This arousal—perhaps resulting from frustration with their performance—may have interfered with their performance. In another study in which he administered propranolol, a drug which blocks autonomic nervous system activity, Eisdorfer found that elderly subjects had much higher test scores than a control group not given the drug.[51]

A.E. David Schonfield, University of Calgary, Alberta, Canada, mentions several other factors that affect ability to learn in the elderly. One is the difficulty they experience switching their concentration from one aspect of a situation to another. Another is the ease with which they are distracted by irrelevant details. He also notes that the elderly tend to have a harder time translating thoughts or words into action. For example, it might take an older person longer to convert the mental note "an octagonal sign means stop" into the automatic act of stopping at an octagonal sign.[52]

Since learning is the first or "acquisitional" step, many of the factors that impair learning in the aged also impede their ability to memorize new material. The effect of aging on memory is one of the most controversial areas of aging research, and is confounded by the different categories of memory described by individual investigators. In a 1977 review of aging and memory, Fergus I.M. Craik, University of Toronto, Canada, says that "primary" memory, or memory for material still at the focus of attention, declines negligibly with age unless the material memorized has to be reorganized, or attention has to be divided between several mental operations at one time.[53]

More substantial age differences occur with "secondary" memory—material already learned, but in the not too distant past. Craik maintains that the decrease in secondary memory stems from older people's failure to effectively and permanently transfer information from short- to long-term memory. He also reports that age differences in recall—retrieving material from memory—are greater than those for recognition.[53] According to Craik, researchers disagree over whether memory for events from the distant past declines with age.

Atchley reports that a greater age-related loss occurs with short-term or recent memory than with remote or old memory. He adds that older people are better at remembering things heard than seen, and are best at remembering things both heard and seen.[41]

Finally, John C. Cavanaugh, Bowling Green State University, Ohio, and Jayne G. Grady and Miriam Perlmutter, University of Minnesota, Minneapolis, concede that older people experience more memory failures in their daily lives. However, they note that older people may also report proportionately more memory loss because they are more sensitive to memory problems.[54]

Some researchers attribute age-related memory loss to poor initial learning. Others point to the failure to use information stored in memory. Another theory proposes that newly learned material interferes with the recall of old information. And material already stored

interferes with memorizing new information.[17] Barry D. McPherson, University of Waterloo, Canada, suggests that the stereotype of memory loss with old age may contribute to this loss by becoming a self-fulfilling prophecy.[17]

Since relatively little is known about the neurophysiological effects of aging on learning, memory, and intellectual competence, biological theories to explain declines in these areas are somewhat tentative. Until recently, the loss of brain tissue, particularly nerve cells, was widely assumed to be a partial explanation for age-related declines in healthy people.[21] Gerontologists attributed this tissue loss to poorer cardiovascular circulation in the elderly, which might starve the brain of oxygen.

The question of aging and intelligence has in recent years received considerable attention from sociologists and historians of science. This is because economic retrenchment at universities has resulted in fewer opportunities for young scientists. It is commonly assumed that scientists are most productive and creative when young. According to Mark Oromaner, Hudson County Community College, North Bergen, New Jersey, if true, a reduced percentage of young scholars in academia would affect the quality of work produced in universities.[55]

One of the earliest and most-quoted works on this subject is a 1953 study in which H.C. Lehman, Ohio University, Athens, examined histories of science to determine the age of various scientists when their most outstanding discoveries were made. He concluded that, although productivity persists into old age, scientists do their highest quality work before the age of 40.[56]

Lehman's study has been challenged by a number of researchers. Harriet Zuckerman and Robert K. Merton, Columbia University, New York, suggest that scientists make their most important contributions at a young age in fields that are highly codified.[57] In such fields, it takes less time for students to master the discipline's theoretical framework, since this framework takes the form of fairly condensed, interrelated laws, rather than voluminous factual material. And Stephen Cole, State University of New York, Stony Brook, notes that Lehman failed to consider that science has been growing exponentially for the past few centuries. The reason for the disproportionate number of contributions from young people is that this growth has meant science has been disproportionately populated by young scientists.[58] Another variation on this theme is Derek J. de Solla Price's oft quoted statement, "80 to 90 percent of all the scientists that have ever lived are alive now."[59] (p. 1)

In his own study of the effects of aging on scientific creativity and productivity, Cole examined the citations and publications of chemists, geologists, mathematicians, physicists, psychologists, and sociologists. He found that productivity peaked in all fields except mathematics—which showed no age effect—from ages 40 to 45, and then declined gradually. Scholars over age 50 were only slightly less productive than those under age 35. Scientists did their highest quality, or most-cited, work from ages 35 to 44, with scholars over 45 slightly less likely to publish highly cited work than those under 35. Cole also did a longitudinal study of mathematicians in which he found that their productivity and creativity remained fairly stable throughout their careers.[58]

Cole believes the reward system of science is partially responsible for scientists' increased productivity with age. He explains, "Since the members of an age cohort who continue to be prolific publishers after the age of 50 are the scientists who have in the past produced significant work and been rewarded, their current research will be of relatively high quality."[58] Of course, as mentioned in an

Table 1: 1978-1980 *SSCI*® derived research fronts on social gerontology. A=research front name. B=number of core papers in the research front. C=number of citing papers in the research front.

A	B	C
Research in developmental psychology and the aged	3	42
Issues in life-span developmental psychology	3	33
Educational gerontology and cognitive performance	5	67
Effect of age on reaction time	2	24
Age differences in fluid and crystallized intelligence	5	102
Study of attitudes toward the aged	8	65
Methodologies in life-span developmental research	2	72

earlier essay on using citation analysis to evaluate faculty,[60] the positive relationship Cole found between age and publication output may not hold if a scholar is diverted to administration.

The effects of aging on cognition represent just a fraction of the social gerontology research now under way. Even so, numerous research fronts on this topic were identified in the *Social Sciences Citation Index*® (*SSCI*®) data base between 1978 and 1980. Table 1 provides a list of these research fronts, which are specialty areas identified when a group of current papers cites one or more core papers for that topic. Each of the core papers was cited at least 11 times between 1978 and 1980, and at least 35 percent of its citations were co-citations with other papers in the cluster. Although the papers in these fronts represent only a few of the hundreds of key documents on aging and intelligence, many proved invaluable when writing this essay. The research front entitled "Effect of age on reaction time," for example, provided two core papers on age-related changes in the nervous system that affect response speed.[39,40] Core publications[19,20,61-63] in the research front, "Age differences in fluid and crystallized intelligence," report studies in which the theory of fluid and crystallized intelligence, mentioned earlier in this essay, is tested and refined.

The role practice and training play in improving cognitive performance in the elderly is discussed in the papers in the research front entitled "Educational gerontology and cognitive performance."[28,64-67] The question of whether declines in intelligence test scores are the result of aging itself, or differences between generations, is discussed in the core papers in the research front, "Research in developmental psychology and the aged."[23-25] The two core documents in the research front, "Methodologies in life-span developmental research," are the seminal studies[30,31] in which sequential analysis, the technique combining cross-sectional and longitudinal study designs, was used. Baltes commented on his paper[31] in a *Citation Classic*™ in *Current Contents*®.[68]

The research front, "Issues in life-span developmental psychology," focuses on a relatively new research perspective in which aging is viewed as another step in development, and the events of childhood and adulthood are considered part of the aging process.[69-71] The research front entitled "Study of attitudes toward the aged"[6-9] focuses on the way different age, race, professional, and ethnic groups view the elderly.

The fact that certain aspects of cognition decline with age should not be taken to mean that intellectual decline is inevitable for all people. The many who do not suffer from senile dementia[72] and other age-related diseases maintain their intellectual functions well into old age. Many of the declines reported here can be avoided or minimized by maintaining good health, by exercising intellectual faculties, by staying socially active, and by allowing the aged more time to learn.[21] Even those changes that do occur with age don't seem to interfere with meeting the personal and professional demands of life. Rather, the elderly develop strategies for adapting to

slower response speeds and other age-related declines. In a 1969 survey of successful professional people, Birren found that these older people coped by becoming more flexible in their goals, recognizing when advice should be taken, conserving their time and resources, and making an effort to "distinguish between critical and extraneous tasks and demands."[73] Patrick Rabbitt, University of Oxford, England, concludes from Birren's study, "In considering the real-life performance of older people, it is naive to regard them as passive victims of a cognitive degeneration of which they are helplessly aware."[74] (p. 623)

For more information on social sciences research fronts, contact Yvonne McGee at the ISI® Search Service; telephone: (800) 523-1850, extension 1274. In clustering for 1983, we are identifying research fronts in social sciences by clustering a combined file for *SSCI* and *Science Citation Index®*. This combined approach is needed in fields such as social gerontology where the artificial and arbitrary separation of the social sciences from the life sciences is unwarranted.

In part two, the economic, social, and political effects of population, or demographic, aging will be reviewed. At that time, social gerontology journals and organizations will be discussed.

* * * * *

My thanks to Joan Lipinsky Cochran and Terri Freedman for their help in the preparation of this essay.

REFERENCES

1. **Garfield E.** The dilemma of prolongevity research—must we age before we die, or if we don't, will we? *Current Contents* (15):5-18, 11 April 1983.
2. **Tibbitts C,** ed. *Handbook of social gerontology.* Chicago: University of Chicago Press, 1960. 770 p.
3. **Herodotus.** (Rawlinson G, transl.) *The history of Herodotus.* New York: Tudor Publishing, 1936. p. 212.
4. **Strabo.** (Hamilton H C & Falconer W, transls.) *The geography of Strabo.* London: Henry G. Bohn, 1856. Vol. II. p. 253.
5. **Fischer D H.** *Growing old in America.* New York: Oxford University Press, 1977. 242 p.
6. **McTavish D G.** Perceptions of old people: a review of research methodologies and findings. *Gerontologist* 11:90-101, 1971.
7. **Tuckman J & Lorge I.** Attitudes toward old people. *J. Soc. Psychol.* 37:249-60, 1953.
8. **Hickey T & Kalish R A.** Young people's perceptions of adults. *J. Gerontol.* 23:215-9, 1968.
9. **Kogan N.** Attitudes toward old people: the development of a scale and an examination of correlates. *J. Abnormal Soc. Psychol.* 62:44-54, 1961.
10. **Butler R N & Lewis M I.** *Aging & mental health.* St. Louis: Mosby, 1973. 306 p.
11. **Almeder R F.** Materialism and the future of aging in America. *Int. J. Aging Human Develop.* 16:161-5, 1983.
12. **Cowgill D O.** A theory of aging in cross-cultural perspective. (Cowgill D O & Holmes L D, eds.) *Aging and modernization.* New York: Appleton-Century-Crofts, 1972. p. 1-13.
13. **Rosen B & Jerdee T H.** The nature of job-related age stereotypes. *J. Appl. Psychol.* 61:180-3, 1976.
14. ----------, The influence of age stereotypes on managerial decisions. *J. Appl. Psychol.* 61:428-32, 1976.
15. **Riley M W.** Telephone communication. 1 March 1984.
16. ----------, *Aging and society: notes on the development of new understandings.* Unpublished lecture delivered at the University of Michigan School of Social Work. 12 December 1983. Ann Arbor, MI. 18 p.
17. **McPherson B D.** The aging process: adaptation to psychological changes. *Aging as a social process.* Boston: Butterworth, 1983. p. 197-221.
18. **Horn J L & Cattell R B.** Age differences in fluid and crystallized intelligence. *Acta Psychol.* 26:107-29, 1967.
19. **Cattell R B.** Theory of fluid and crystallized intelligence: a critical experiment. *J. Educ. Psychol.* 54:1-22, 1963.
20. **Horn J L & Cattell R B.** Refinement and test of the theory of fluid and crystallized general intelligences. *J. Educ. Psychol.* 57:253-70, 1966.
21. **Goleman D.** The aging mind proves capable of lifelong growth. *NY Times* 21 February 1984. p. C1; C5.

22. **Baltes P B & Schaie K W.** The myth of the twilight years. *Psychol. Today* 7(10):35-40, 1974.
23. ----------. On the plasticity of intelligence in adulthood and old age. *Amer. Psychol.* 31:720-5, 1976.
24. **Horn J L & Donaldson G.** On the myth of intellectual decline in adulthood. *Amer. Psychol.* 31:701-19, 1976.
25. **Horn J L.** Faith is not enough. *Amer. Psychol.* 32:369-73, 1977.
26. **Horn J L, Donaldson G & Engstrom R.** Apprehension, memory and fluid intelligence decline in adulthood. *Res. Aging* 3:33-84, 1981.
27. **Schaie K W.** Translations in gerontology—from lab to life. *Amer. Psychol.* 29:802-7, 1974.
28. **Botwinick J.** Intellectual abilities. (Birren J E & Schaie K W, eds.) *Handbook of the psychology of aging*. New York: Van Nostrand Reinhold, 1977. p. 580-605.
29. **Schaie K W, Labouvie G V & Barrett T J.** Selective attrition effects in a fourteen-year study of adult intelligence. *J. Gerontol.* 28:328-34, 1973.
30. **Schaie K W.** A general model for the study of developmental problems. *Psychol. Bull.* 64:92-107, 1965.
31. **Baltes P B.** Longitudinal and cross-sectional sequences in the study of age and generation effects. *Hum. Develop.* 11:145-71, 1968.
32. **Schaie K W & Hertzog C.** Fourteen-year cohort-sequential analyses of adult intellectual development. *Develop. Psychol.* 19:531-43, 1983.
33. **Schaie K W,** ed. *Longitudinal studies of adult psychological development*. New York:Guilford Press, 1983. 332 p.
34. **Birren J E & Morrison D F.** Analysis of the WAIS subtests in relation to age and education. *Gerontology* 16:363-9, 1961.
35. **Botwinick J.** Disinclination to venture response *versus* cautiousness in responding: age differences. *J. Genet. Psychol.* 115:55-62, 1969.
36. **Klodin V M.** *Verbal facilitation of perceptual-integrative performance in relation to age*. PhD dissertation, Washington University, 1975.
37. **Doppelt J E & Wallace W L.** Standardization of the Wechsler Adult Intelligence Scale for older persons. *J. Abnormal Soc. Psychol.* 51:312-30, 1955.
38. **Schaie K W, Rosenthal F & Perlman R M.** Differential mental deterioration of factorially "pure" functions in later maturity. *J. Gerontol.* 8:191-6, 1953.
39. **Weiss A D.** The locus of reaction time change with set, motivation, and age. *J. Gerontol.* 20:60-4, 1965.
40. **Botwinick J & Thompson L W.** Components of reaction time in relation to age and sex. *J. Genet. Psychol.* 108:175-83, 1966.
41. **Atchley R C.** *The social forces in later life*. Belmont, CA: Wadsworth, 1980. 468 p.
42. **Welford A T.** Sensory, perceptual, and motor processes in older adults. (Birren J E & Sloane R B, eds.) *Handbook of mental health and aging*. Englewood Cliffs, NJ: Prentice-Hall, 1980. p. 192-213.
43. **Riegel K F & Riegel R M.** Development, drop, and death. *Develop. Psychol.* 6:306-19, 1972.
44. **Kleemeier R W.** Intellectual change in the senium. *Proceedings of the Social Statistics Section of the American Statistical Association*, 7-10 September 1962, Minneapolis, MN. Washington, DC: ASA, 1962. p. 290-5.
45. **Atchley R C.** Telephone communication. 18 January 1984.
46. **Baltes P B & Willis S L.** Plasticity and enhancement of intellectual functioning in old age: Penn State's Adult Development and Enrichment Project (ADEPT). (Craik F I M & Trehub S E, eds.) *Aging and cognitive processes*. New York: Plenum Press, 1982. p. 353-89.
47. **Willis S L, Blieszner R & Baltes P B.** Intellectual training research in aging: modification of performance on the fluid ability of figural relations. *J. Educ. Psychol.* 73:41-50, 1981.
48. **Perone M & Baron A.** Age-related effects of pacing on acquisition and performance of response sequences: an operant analysis. *J. Gerontol.* 37:443-9, 1982.
49. **Hoyer W J & Plude D J.** Attentional and perceptual processes in the study of cognitive aging. (Poon L W, ed.) *Aging in the 1980s*. Washington, DC: American Psychological Association, 1980. p. 227-38.
50. **Eisdorfer C.** Arousal and performance: experiments in verbal learning and a tentative theory. (Talland G A, ed.) *Human aging and behavior*. New York: Academic Press, 1968. p. 189-216.
51. **Eisdorfer C, Nowlin J & Wilkie F.** Improvement of learning in the aged by modification of autonomic nervous system activity. *Science* 170:1327-9, 1970.
52. **Schonfield A E D.** Learning, memory, and aging. (Birren J E & Sloane R B, eds.) *Handbook of mental health and aging*. Englewood Cliffs, NJ: Prentice-Hall, 1980. p. 214-44.
53. **Craik F I M.** Age differences in human memory. (Birren J E & Schaie K W, eds.) *Handbook of the psychology of aging*. New York: Van Nostrand Reinhold, 1977. p. 384-420.
54. **Cavanaugh J C, Grady J G & Perlmutter M.** Forgetting and use of memory aids in 20 to 70 year olds everyday life. *Int. J. Aging Human Develop.* 17:113-22, 1983.

55. **Oromaner M.** The quality of scientific scholarship and the "graying" of the academic profession: a skeptical view. *Res. High. Educ.* 15:231-9, 1981.
56. **Lehman H C.** *Age and achievement*. Princeton, NJ: Princeton University Press, 1953. 359 p.
57. **Zuckerman H & Merton R K.** Age, aging, and age structure in science. (Merton R K.) *The sociology of science*. Chicago: University of Chicago Press, 1973. p. 497-559.
58. **Cole S.** Age and scientific performance. *Amer. J. Sociol.* 84:958-77, 1979.
59. **Price D J D.** *Little science, big science*. New York: Columbia University Press, 1963. 118 p.
60. **Garfield E.** How to use citation analysis for faculty evaluations, and when is it relevant? Part 2. *Current Contents* (45):5-14, 7 November 1983.
61. **Cattell R B.** *Abilities: their structure, growth, and action*. Boston: Houghton Mifflin, 1971. 583 p.
62. **Horn J L.** Organization of abilities and the development of intelligence. *Psychol. Rev.* 75:242-59, 1968.
63. ----------. Organization of data on life-span development of human abilities. (Goulet L R & Baltes P B, eds.) *Life-span developmental psychology*. New York: Academic Press, 1970. p. 423-66.
64. **Hoyer W J, Labouvie G V & Baltes P B.** Modification of response speed deficits and intellectual performance in the elderly. *Hum. Develop.* 16:233-42, 1973.
65. **Furry C A & Baltes P B.** The effect of age differences in ability-extraneous performance variables on the assessment of intelligence in children, adults, and the elderly. *J. Gerontol.* 28:73-80, 1973.
66. **Baltes P B & Labouvie G V.** Adult development of intellectual performance: description, explanation, and modification. (Eisdorfer C & Lawton M P, eds.) *The psychology of adult development and aging*. Washington, DC: American Psychological Association, 1973. p. 157-219.
67. **Labouvie-Vief G & Gonda J N.** Cognitive strategy training and intellectual performance in the elderly. *J. Gerontol.* 31:327-32, 1976.
68. **Baltes P B.** Citation Classic. Commentary on *Hum. Develop.* 11:145-71, 1968. *Current Contents/Social & Behavioral Sciences* 13(18):16, 4 May 1981.
69. **Baltes P B & Willis S L.** Toward psychological theories of aging and development. (Birren J E & Schaie K W, eds.) *Handbook of the psychology of aging*. New York: Van Nostrand Reinhold, 1977. p. 128-54.
70. **Overton W F & Reese H W.** Models of development: methodological implications. (Nesselroade J R & Reese H W, eds.) *Life-span developmental psychology*. New York: Academic Press, 1973. p. 65-86.
71. **Reese H W & Overton W F.** Models of development and theories of development. (Goulet L R & Baltes P B, eds.) *Life-span developmental psychology*. New York: Academic Press, 1970. p. 115-45.
72. **Garfield E.** Senility: a major health problem in need of a solution. *Essays of an information scientist*. Philadelphia: ISI Press, 1983. Vol. 5. p. 138-42.
73. **Birren J E.** Age and decision strategies. *Interdisciplin. Top. Gerontol.* 4:23-36, 1969.
74. **Rabbitt P.** Changes in problem solving ability in old age. (Birren J E & Schaie K W, eds.) *Handbook of the psychology of aging*. New York: Van Nostrand Reinhold, 1977. p. 606-25.