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THE AGING DIMENSION

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AGING AND HUMAN PERFORMANCE

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Human performance is subject to vast individual differences due to genetic potential, environmental opportunities, life history, and differential societal practices in vogue at particular historical times. Thus universal principles are difficult to specify. Nevertheless, age-related changes in sensorimotor and cognitive performance present a problem in their own right as well as being precursors to other health problems. Sensorimotor and cognitive performance changes with age have been observed in three broad areas: 1) sensation and perception (e.g., vision, taste, audition); 2) psychomotor skills (e.g., coordination, muscular strength, reaction time); and 3) cognition (e.g., attention, decision-making, intelligence, learning, memory, signal detection).

The proportion of individuals in the population showing adverse changes in sensorimotor and cognitive performance tends to increase with advancing age. However, there is great variability in the extent and nature of performance change with aging. There is variability across sensory modalities and tasks in any given person at a particular age. There is also great variability in performance across different individuals at various ages and in these individuals' life-course patterns of performance. For example, my own studies of intellectual functioning show that, contrary to conventional wisdom, scarcely any individuals up to age 60, and less than half of individuals even at age 80, showed reliable decrements over a seven-year period.

Performance also differs across different societies, different historical periods, and among individuals differing in demographic characteristics (e.g., education, sex, socioeconomic status). Looking to the future, the population cohort reaching old age in 1990 will have had a reduction in the experience of childhood disease,

improved nutritional history, and superior life-time health care over the current population of the elderly. They will also have a sharply increased educational background. It must consequently be expected that the old people of the 1990s will function at higher levels of cognitive performance than do their predecessors at a like age today.

Such social and temporal differences in performance suggest that biological and psychosocial factors interact to produce the observed age-related levels of performance. These multifaceted influences suggest the likelihood of a good potential that psychosocial and engineering interventions may be possible which could prevent, reverse, or compensate for age-related declines in performance. In other words, the evidence tends to support the principles announced in Matilda Riley's opening chapter.

THE NATURE OF AGE-RELATED CHANGES IN HUMAN PERFORMANCE

In full recognition of the wide ranges and sources of variability, average patterns of age-related changes in sensorimotor and cognitive skills have been described. It must be emphasized, however, that these findings refer not only to current conditions but also to current methods of testing. Many of these tests are designed for laboratory rather than real-life conditions; they omit such components as motivation or emotion; and they are appropriate for the young, for use in schools or in entry-level jobs, rather than for people in middle and later life. Moreover, all too often these tests are applied to cross-sectional samples, failing to trace age changes longitudinally in the same subjects as they grow older through time.

Sensory and Perceptual Modalities

Although there are no reliable population estimates, a number of well-controlled small sample studies exist which help to identify the major dimensions of the problem. Modalities of greatest concern (and those best studied) include vision, hearing, and perceptual masking.

VISION. Beginning in the fourth decade of life, structural changes occur in the eye that lead to a lessening of light transmission and accommodation power. Thickening and yellowing of the lens reduces the amount of light reaching the retina and decreases sensitivity to the shorter wave lengths of the visible spectrum. Older persons therefore have difficulty in discriminating between blue, blue-green, and violet; reduced accommodative power affects accuracy of distance vision, sensitivity to glare, binocular depth perception, and color sensitivity. Circulatory and metabolic changes, commonly beginning with the sixth decade, lead to reduction of the size of the visual field, and decreased sensitivity to flicker and to low quantity of light. Perceptual changes with age lead to an increasing tendency to retain the initial perception of the stimulus, with consequent difficulty to reorganize that perception. Age-related decrements in visual ability have a limiting effect on the older adult's ability to use buildings, facilities, and other spatial environments, and also endanger drug compliance because of lessened color discrimination.

AUDITION. Some degree of hearing loss has been reported as early as age 32 for men and age 37 for women as a function of presbycusis. Resulting decrements affect threshold for pure tones, speech, and pitch discrimination, deficits likely to interfere with the older person's ability to communicate. High-frequency loss introduces difficulty in discriminating phonetically similar words, and increased noise level can enhance sound discrimination problems. By the time the seventies are reached, some hearing loss is virtually universal, but sex differences exist, such that men have greater loss at higher frequencies than do women and women have greater loss at lower frequencies than do men.

PERCEPTUAL MASKING. This phenomenon is the failure to perceive a visual or auditory stimulus if the sound or display is followed too quickly by a second competing stimulus. Many adults over 60 require increased intervals between successive stimuli in order to discriminate them. Longer scanning time is also required with increasing age, particularly when complex information is to be digested. It is not that the world is becoming too complex for the older person to manage; what increases in difficulty is the manner in which that person must digest the information needed to cope successfully, as discussed below.

Psychomotor Skills

Large movements made at maximum speed show substantial slowing with age due to muscular limitations. However, most movements involved in everyday tasks are not limited by muscular factors but by the speed of decisions required to guide movements and to monitor them. Changes with age in movements of the latter type are relatively small when the movements are simple and when they can be prepared in advance. Greater age changes occur when movements cannot be prepared in advance. In that case, more decision time is required, and the tendency to monitor movements is known to increase with age also. The latter may be an aspect of increased cautiousness and appears to compensate for the reduced signal strength in the sense organs and central nervous system. When older persons have sufficient time to inspect signals and to monitor their movements, they will be slower but more accurate than younger persons; when such opportunity is missing, they will be less accurate. As a consequence, in industrial work, demands for speed are often more adverse than are demands for moderately heavy physical effort by the older worker.

Cognitive Performance.

INTELLIGENCE. Age-related change in intelligence is not a uniform phenomenon, but must be differentiated by type of intellectual ability. For example, overlearned and highly practiced abilities, sometimes called "crystallized" abilities, tend to reach a peak in middle adulthood and show little decline until the mid-seventies and early eighties. Abilities involving the detection of novel relationships, sometimes called "fluid" abilities, on the contrary peak early in adulthood and show slow but steady decline from as early as the forties, particularly if measured by highly speeded tests. Overlearned abilities such as recognition vocabulary and numerical skills tend to decline only minimally in very advanced age. Those involving new learning generally begin to show consequential impairment by the late sixties.

MEMORY. Age-related difficulties in memory are also not uniform, but involve different aspects of memory function differentially. By the sixties there is demonstrably increased difficulty in encoding information, accounting for the observation that recent events are often less well remembered than are more distant ones. There is no demonstrated decline in short-term memory, but less efficient strategies appear to be used in encoding information in long-term store. In addition, there are also retrieval difficulties. These are more pronounced for free recall than for recognition, and for auditory than for visual materials. Older persons are thought to use retrieval information less effectively and to suffer from what may be termed an "information overload."

LEARNING ABILITY. There is no question that considerable learning ability is retained throughout adult life. However, the older learner is at a disadvantage when the required response time is short, and age differences in performance have been found even under self-paced conditions. The performance of many older learners is also limited by less effective encoding and organizational strategies. Older learners also suffer from response competition and other interference effects.

DECISION-MAKING AND CHOICE BEHAVIORS. When measured by currently used tests of problem-solving behavior, the major age change seems to be additional time required to reach accuracy levels shown by young adults. Slowing sensory and perceptual processes make it likely that many older people may make mistakes under test conditions by simplifying their conceptual frameworks even when this is maladaptive, or by failing to spend as much time as is required for them to obtain adequate solutions because of real or perceived pressures "to get on with it." For today's cohort of elderly there may also be a fear about risk taking engendered by the Great Depression, even though it is the older problem solver who must take increasing risks to survive well in our complex society.

Inadequacies of current testing procedures may be particularly critical in areas such as decision-making, which in many real-life situations must be based on accumulated experience or "wisdom." Efforts are now under way to design improved measures and research designs that may reflect components of cognitive performance that develop in the middle and later years. Thus, future findings may well report age-related strengths that complement, and sometimes compensate for, currently recognized age-related deficits.

AGE-RELATED CHANGES AS SYMPTOMS OF ILLNESS

Behavioral deficits frequently occur as a result of illness-related physiological changes. Among sensory disorders, for example, visual deficits common in the elderly are often a function of presbyopia as well as the early phases of treatable diseases such as glaucoma and cataracts, the incidence of which increases with advancing age. Likewise, hearing impairment most frequently is associated with presbycusis, and perceptual difficulties may be associated with mild aphasias. Sensory difficulties may be further increased due to untreated metabolic disturbances as well as to the side effects of the interaction of prescription and/or over-the-counter medications.

Among neurological disorders, perhaps the most profound behavioral changes in advanced age are associated with senile dementia of the Alzheimer type. This affliction results in progressive behavioral deterioration involving memory loss and general decomposition of behavioral competence. However, major behavioral consequences are also seen in other neurological disorders, such as Parkinsonism and multiple infarct dementia (subsequent to cerebrovascular accidents) resulting in intellectual and/or psychomotor deficits which may prevent individuals from continuing independent and productive lives.

AGE-RELATED CHANGES AS PRECURSORS TO PHYSICAL AND MENTAL HEALTH AND TO RELATED SOCIAL PROBLEMS

Accidents

Even modest declines in sensory and perceptual efficiency can lead to changes in accident patterns. Incidence of accidents increases with age in unfamiliar environments, as well as in those which have become more hazardous to the elderly due to poor visual and auditory conditions or where great agility and motor coordination are required. In familiar industrial settings, incidence of

accidents actually decreases with age, but when accidents do occur they tend to be more serious.

Ability to Perform Social Roles

Most people are well able to maintain their job- and family-related roles into advanced age. In many individuals, there may well be improvements with aging in interpersonal competence, knowing what responses a situation requires, commitment, or ability to cope. However, the probability increases that as the late seventies and eighties are reached many persons will become unable to perform any vocational roles or to exert other than quite dependent roles when remaining in a family setting. Memory deficits, loss of adequate motor coordination, and difficulties in comprehending the complexities of the modern environment are some of the factors particularly important in creating difficulties for many of the very old to continue their lives within the community or to be adequately supportable within a family setting.

Ability to Maintain One's Health

Declines in behavioral competence associated with age may have deleterious consequences for persons' ability to engage in adequate health care. An additional common problem is loss of appetite, often associated with changes in the taste receptors, leading to poor nutrition. Memory loss and defective color vision may result in inadequate drug compliance and resulting health problems. Indeed, the lower educational level of the current cohorts of elderly may impair the ability of many persons to communicate adequately with their physicians or to participate in the planning and execution of their own health care.

CAUSAL FACTORS IN AGE-RELATED CHANGES

Although there is a massive descriptive literature on both physiological and psychological changes associated with advancing age, there is only limited information on the behavioral correlates of biological age changes, and even more sparse data on specific interactions between biological and psychosocial factors. For example, it is suspected that adverse changes in the synchrony between the autonomic nervous system and central nervous system occurring with advancing age may also adversely affect intellectual performance, particularly in job roles which require complex decision making. These complex interactions are particularly worthy of study, since a better understanding of the reciprocal relations between biological and psychosocial factors may suggest alternate modes of intervention strategies.

REVERSAL OR COMPENSATION OF COGNITIVE DECLINE

Some of the most exciting recent developments are the attempts to program systematic interventions for the prevention, reversal, or compensation of cognitive decline in older persons. This work, however, is only in the early stages of development.

Studies of my own, done in collaboration with my wife and colleague, Sherry Willis, are beginning to specify the conditions under which certain cognitive declines may be reversed. Working with elderly subjects from my earlier longitudinal studies, so that their intellectual histories are known, we have been conducting experiments to test the effects on performance of training in spatial orientation and inductive reasoning. Early results are encouraging. Substantial improvements were observed in about two-thirds of the subjects, and, most importantly, 40% of those subjects who had shown significant declines over the previous fourteen years were restored to the earlier level at which their decline had begun.

These and other recent studies suffice to demonstrate the value of intervention efforts that involve the practice of memory or learning strategies as well as the provision of incentives to increase performance. Environmental measures have also been taken to improve performance by means of changing social roles, modifying job complexity, or redesigning the physical environment.

Some of the most promising interventions involve a systematic investigation of those aspects of the physical environment which could be redesigned to lessen stress on the aging individual without impairing the quality of the environment for other population segments. Redesign efforts would compensate for both decreased sensory efficiency and lower speed of older persons. Prime candidates for such redesign include removal of safety hazards posed by inadequate illumination, glare, and noisy environments, as well as a reexamination of the adequacy of signs (e.g., easily confused colors and shapes, and spacing of information on highways to meet the needs of reduced processing speed in older persons).

Attention should also be given to the possibility of redesigning work situations to maximize performance for the older worker. For example, routine work could be redesigned to contain aspects which would tend to stimulate cognitive functioning. Although computerization might initially provide additional stress for the older worker, it is likely that attention to the characteristics of older persons in software and apparatus design may pay large dividends by reducing memory loads and compensating for losses in response speed.

Increased efforts are also needed to improve performance characteristics and to encourage increased prescription and use of prostheses designed to offset deficits in vision, hearing, and physical mobility. Of particular promise may be the introduction of relatively simple microcomputer devices serving as memory-related and other behavioral protheses.

FUTURE GOALS

For the future, goals should include recognition by health professionals that old individuals are worthwhile recipients of quality care, recognition by the educational establishment that the older learner is a prime concern of the formal and informal educational system, and recognition by business and industry of the value of the mature worker and of the need of that worker for continued on-the-job training and other obsolescence-resistant mechanisms. Equally important will be measures to get old people to recognize that most of the perceived behavioral deficits of old age can be compensated for and to encourage them to take a greater role in the management of their health and continued optimal functioning.

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