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RESEARCH ON THE PSYCHOLOGY OF AGING:
Principles, Concepts and Theory

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INTRODUCTION
Time is the messenger of the gods, a messenger who passes through space, matter, energy, and minds. This metaphor is meant to capture the ubiquity of time not only in the process of aging but as a pervasive factor in the organization of all phenomena and their explanations (see Fraser, 1966).

This chapter attempts to provide an orientation and perspective on research in the psychology of adult development and aging as well as to serve as an introduction to the chapters that follow, in which the state of research and knowledge on a wide range of subtopics will be reviewed. Activity and research in this field continues to grow at a rapid pace. This was noted in the 1977 edition of the Handbook of the Psychology of Aging (Birren and Renner, 1977), in which it was estimated that there was a doubling of the total volume of published literature over a 15-year period. The period for this rate of doubling has now decreased to 10 years. A 1983 review of the subject for the Annual Review of Psychology (Birren, Cunningham, and Yamamoto, 1983) pointed out that it was increasingly difficult to embrace the field as a whole, not only for theoretical reasons, but also because of the practical fact that the volume of published research has increased to the almost unmanageable total of over a thousand articles a year.

Psychology has many scientific traditions: biological, behavioral, and social. In addition, it has traditions of being experimental, descriptive, phenomenological, and clinical. A large volume of information from allied disciplines influences its subject matter as well. Such a range provides a fertile context for the subject but also makes it very difficult to present an integrated picture of the state of knowledge. The scope of the field and, more recently, the degree of its activity and research productivity have resulted in the creation of islands of knowledge with little communication between them. The theory for the most part is no more than microtheory, in areas of cognition, memory, perception, social roles, or selected aspects of emotions and personality. The psychology of the adult portion of the life span is a growth area of research and teaching into which new investigators are carrying the concepts and traditions of the subfields of their own background. Although this has led to a healthy input of new concepts and challenges, it is to be hoped that the field will not become ingrown with barriers to in-
formation exchange and transfers of research methods, design, and methods of data analysis.

The traditional question of psychology is, "How is behavior organized?" Increasingly this question is shifting to "How does behavior become organized?" One might also add the question of how behavior becomes disorganized for there is emerging a psychopathology of aging. Psychology for the most part has been attending to the identification of the elements of behavior, but increasingly it will turn to issues of differentiation, development, aging, and the disorganization of behavior.

THE TASK OF PSYCHOLOGY

The task of the psychology of adult development and aging is to explain how behavior becomes organized and, in selected instances, how it becomes disorganized. The organization of behavior from conception to death is the subject matter of ontogenetic psychology. In practice, ontogenetic psychology is divided into an early phase—the developmental psychology of childhood, adolescence, and young adulthood—and a second phase—middle and old age. Developmental psychology usually refers to the increasing differentiation of the organism up to the age of physical maturity. Whereas adult behavior can have antecedents in childhood and any distinctions between development and aging may be somewhat arbitrary, early development appears to be characterized by relatively rapid increases in size, form, and function with increasing age. After adolescence, changes in form and size are slow, though function continues to differentiate as the individual adapts to the environment and personal needs.

The fertilized egg appears to have purpose in systematically increasing its size and capacity for self-regulation. At the time of birth, the child is able to regulate some, if not yet all, of its vital processes without assistance from outside persons. Increasingly with age the child is able to regulate physiological processes as well as environmental interactions. In teleological terms, the purpose of the organism is to establish biological, behavioral, and social regulation so that it may function through any perturbations of the physical and social environment without reductions that are risks to its survival. Although such a definition implies that the individual ceases to differentiate after adolescence, the basic question for ontogenetic psychology still remains how behavior becomes organized and differentiated over a lifespan.

DEFINITIONS

It is useful at this point to present some of the definitions and concepts that have influenced research on adult development and aging. Many articles and books are written about aging without any reference to the definition of aging that guided the thinking of the authors. It is perhaps more common than not that definitions of aging are avoided with the tacit assumption that most people believe themselves to be considering the same phenomena. An examination of three previous handbooks of aging (Finch and Hayflick, 1977; Birren and Schaie, 1977; Binstock and Shanahan, 1976) suggests, however, that there is a hierarchy in which biologists provide definitions of aging most often, psychologists rarely, and social scientists almost never. This leads to the thought that aging and time as variables enjoy a different status among the sciences. Undoubtedly, the lack of formal definitions helps block articulation of knowledge between the various sciences that study aging.

Cowdry (1942, p. 15) gave a statement that represents an informal definition of aging. "Since almost all living organisms pass through a sequence of changes, characterized by growth, development, maturation and finally senescence, ageing presents a broad biological problem." Apparently there is an assumption among biologists that they are studying the length of life of an organism. For example, Cowdry’s following quotation of Jenning’s definition clearly identifies the length of life as a dependent variable: "There can be no doubt then in all animals from the single-celled protozoa through the invertebrates to man, the length of life is largely determined by inheritance." (Cowdry, 1952, p. 56). Cowdry further distinguished two main points of view not unlike those that exist in psychology; by student aging as aates cumul inse revealed to the psychological interaction. The other in aged or, to infection disturbance what are caphairments. we have comus an exog to the nurtur developmen. Some biohinitions of aging to Comfort behavior oft to a decrease ment." (Con the word sens to narrow th Handler (1974) definition of a mature dependent, ess trinsic to all with thepass increasinally of the environment probability of dying. Here ones organism can adjust to the pe. Self-regulation biological, beh. Ander: restrictive for organization of clones outcome of dying. Birren and a general defin scienc that incremen fundamental fund changes that occur in mature orga.
psychology: “Two conflicting views are held by students of aging and man. One considers aging as an involuntary process which operates cumulatively with the passage of time and is revealed in different organ systems as inevitable modifications of cells, tissues, and fluids. The other view interprets the changes found in aged organs as structural alterations due to infections, toxins, traumas, and nutritional disturbances or inadequacies giving rise to what are called degenerative changes and impairments.” (Cowdry, 1942, p. 16). Thus what we have contrasted here is an endogenous versus an exogenous view of aging that is similar to the nurture versus nature viewpoints in developmental psychology.

Some biologists have offered narrower definitions of aging than did Cowdry. According to Comfort: “Senescence is a change in the behavior of the organism with age, which leads to a decreased power of survival and adjustment” (Comfort, 1956, p. 190). Notice that the word senescence was used in place of aging to narrow the implications of the definition. Handler (1960, p. 200) gave a still narrower definition of aging: “Aging is the deterioration of a mature organism resulting from time dependent, essentially irreversible changes intrinsic to all members of a species, such that, with the passage of time, they may become increasingly unable to cope with the stresses of the environment, thereby increasing the probability of death.”

Here one sees the implication that the old organism can no longer self-regulate and adjust to the perturbations of the environment. Self-regulation, however, exists at three levels, biological, behavioral, and social. For this reason, Handler’s definition, while precise, is too restrictive for psychologists for whom the organization of behavior over the life span implies outcomes in addition to the probability of dying.

Birren and Renner (1977, p. 4) have offered a general definition of aging for the behavioral sciences that recognizes that there can be incremental functions as well as decremental changes that occur over the adult life span: “Aging refers to the regular changes that occur in mature genetically representative organisms living under representative environ-

mental conditions.” By introducing the phrase “genetically representative,” one avoids mixing aging with unusual phenomena produced by rare genetic problems or by unusual environmental conditions that do not represent the typical pattern of a species.

Aging implies a representational organism living under representative conditions (see Birren, 1959a, pp. 26–30). The formal properties of definitions of aging involve one or more independent variables whose influence is thought to bring about the changes in the nature of frequency of the dependent variable over the life span of the individual organism.

Psychologists are much less likely than biologists to use length of life as their primary dependent variable. Nevertheless, we should not neglect the fact that ontogenetic psychology has a contribution to make in understanding why there is a characteristic shape to the mortality curve with age. Mortality rates are high for infants, regularly decline to a minimum at about age 10, and then rise progressively throughout the remainder of the life span. Psychologists are more often interested in aspects of behavior only some components of which may be related to length of life. For this reason, definitions of aging usually offered by biologists are too restrictive for psychologists who are interested not only in aspects of behavior that are related to life-limiting biological phenomena or to the probability of dying, but also to other aspects of behavior that may reveal increments in functional capacity or late-life differentiation.

Due to the fact that the quality or quantity of behavioral functions may show increments or decrements with the passage of time, the authors believe that either an exclusively biological or social definition of aging would be too narrow. They take the term “aging” to imply some typicalness of change over time. Consider, for example, the case of Antarctic penguins raised in a tropical environment. The changes in their physiological disease patterns as well as in their behavior with age might be expected to be very different from those exhibited in their “normal” environment. In like manner, a tropical mammal reared over a life span in the Antarctic might also be expected to show different patterns of change.
One of the classical approaches to the study of the behavior changes of animals with age is to keep them in small cages over their lifespan. Presumably the rat or mouse, both of which are wide-ranging animals when living in natural conditions, would be expected to show a very different pattern of change with age than when housed over a lifetime in such a way that their movements and sensory input are artificially restricted by the usual laboratory conditions. Similarly, germ-free environments created to prevent unusual infectious diseases may not be regarded as fostering “normal aging” in a biological sense since the animals might not show behavior with age that is typical of their species when living under conditions for which they were selected or adapted. Correspondingly, parasitic diseases or infectious diseases of the respiratory tract are not regarded as typical features of aging for the usual laboratory animal. Poor problem-solving ability in rats reared over a lifetime in restricted caging should not be regarded as a typical result of the way the species age. Conversely, experiments that enrich the environments of laboratory rats probably may not be regarded as a means of enhancing the species potential but rather of adding back something that was lost because of artificial laboratory conditions. In this vein, supplying the opportunity for environmental exploration is like supplying a vitamin to an artificially vitamin-restricted group of animals.

Thus typicalness of the genetic background of a species as well as typicalness of environmental circumstances both enter into the psychologist’s attempt to identify the usual pattern of change for the species. To some extent there is a conflict of interest between behavioral scientists and biological scientists in controlling the environments in which laboratory animals live. Biologists wish to exclude extraneous pathogens and reduce genetic variability, whereas psychologists are primarily interested in having an organism live under conditions somewhat like those under which it evolved or is commonly found.

Diseases associated with age—such as cancer, cardiovascular disease, cerebrovascular disease, or kidney disease—are not necessarily primary manifestations of aging. They may be secondary manifestations of underlying biological processes that predispose organisms to the expression of any disease. In this sense, a general change in immune processes might be reflected in increased susceptibility to a number of diseases with advancing age. The typicalness of disposition to disease lies in the susceptibility resulting from a universal alteration in the organism.

**METATHEORETICAL ISSUES**

Throughout recorded history mankind has apparently thought not only about its own relatively limited life span but about immortality. Gruman (1966) reviewed the history of ideas about longevity and earlier beliefs about ways of defeating mortality and extending the life span. Legends about death, immortality, and aging are still a part of our culture today. Found in contemporary writing are echoes of early legends of healing waters and fountains, of people living in remote regions of the world who are very long-lived and possess vital secrets about life. There is also the legend that the people of ancient times not only lived longer than they do now but lost the secret of long life, if not of immortality, when they fell from grace.

It was the middle of the last century that modern experimental science began testing many of the older ideas about aging. Early thoughts about aging emphasized the replacement of lost characteristics. If an old animal became cold in the process of dying, one might rejuvenate it by providing heat. Benjamin Franklin thought that an organism lost some vital process with age that could be rejuvenated by electric shock. A similar focus on the replacement of lost characteristics is manifested by attempts at the rejuvenation of sexual activity. If the male animal shows a reduction in sexual activity in the later years, restitution of the sexual activities might make the animal increasingly long-lived. We know that such attempts at restitution do not necessarily engage an underlying mechanism that paces the human life cycle.

In his excellent book on image, Boulding (1956) notes two opposing forces in history. One of these is the tendency for organizations to run down and eventually become chaotic. Thermodynamically speaking, this tendency
would be expressed by the Second Law. The end of the universe, according to this picture, will be a uniformly formless soup. The contrasting view is that there is a tendency for living organisms to differentiate and acquire increasing complexity with the passage of time. Boulding notes that in the course of the history of the universe we observe an increasing complexity of organization culminating at present in man and his societies (1956, p. 19). Whether or not there is a trend in the universe toward increasing organization or disorganization is well beyond the scope of this chapter. However, we should note the relevance of the concept of two opposing trends, one toward an increasing and the other toward a decreasing complexity of function of an organism with age. Perhaps the ultimate disorganization of an organism begins when the complex control mechanisms that exist in its central nervous system lose their effectiveness in maintaining the dynamic equilibrium necessary to adapt and survive changes in the physical and social environments.

If the task for general psychology is to explain how behavior is organized, the task for ontogenetic psychology is to explain how behavior becomes organized over the course of life. It should be pointed out that answering the question of how behavior is organized does not explain how it becomes less organized or disorganized. A clear illustration of this truth can be found in the conceptual revolution created in biology by Darwin's theory of evolution. Although his predecessors had classified the species and created the discipline of taxonomy, they failed to offer a theory of how the organization of the species had come about. Since evolutionary theory was a dynamic theory (one involving time), it had to wait, in turn, upon the discovery of the chemical structure of the gene before the mechanism of transmission of the controls over size, form, and functions of the members of a species could be identified.

It is suggested that as the various sciences become more mature (gain more facts and theory), their focus shifts from a description of structures to considerations of how structures evolve over time. The physical sciences in particular are not only occupied with explaining the organization of matter, but also how it becomes organized over time. Hierarchically, the behavioral sciences take as given the existence of the universe and its species and are only minimally concerned with theories about their genesis. The theory of evolution, of course, conflicted with the theogenetic interpretation that there was a special and nearly instantaneous creation of all things. However, it is appropriate to point out the hierarchical implications of the establishment of order in the following list.

1. **Theogenesis**: How did God, the gods, or the ultimate force come into being? Theological differences arise as a result of the way in which the God force is considered, whether as static or living and/or evolving.
2. **Cosmogenesis**: How did material things come into being? How was the universe established? Here physical science wrestles with theoretical issues of material origin as a result of a “big bang” or some other circumstance. An understanding of the evolving nature of the universe is also a goal of cosmogenesis.
3. **Phylogenesis**: How did the many species come to exist? This raises the question of the evolution and extinction of animal species.
4. **Coenogenesis**: How did mankind’s institutions of social life come into being? What is their course over time? This relatively new term, *coenogenesis*, was introduced by Schroots (1983) to refer to the history of social institutions. The prefix *coen* refers to things held in common. A corollary word would be *coenobium*, which refers to life in a community.
5. **Ontogenesis**: How did the individual come to be and what is the course of the individual existence? Ontogenesis implies the existence of previous structures and functions. Thus, the individual would not exist unless there was an antecedent phylum of which he was an individual representative, as well as of the institutions that had been created by previous members of the same phylum. The individual grows up and grows old under the control of his phylogenetic history, of his unique heredity, and of the particu-
lar culture into which he is born and lives. In a sense, the content of culture is in large part the equivalent of DNA; that is, culture is the DNA of society and contributes to the differentiated forms of behavior. The course of behavior over the life of an individual would appear to have three influences: the phylogenetic (or heredity), the cultural, and individual choice and adaptation. Thus, aging can also be viewed as resulting from these three forces, which supply the dynamic quality or direction to the entire course of life.

To emphasize the difference in the sets of variables, Schroots and Birren (1980) proposed that aging be viewed as consisting of three components. The process of biological aging, which resulted in increasing vulnerability and a higher probability of dying, was identified as senescing. Concurrent with senescing, individuals show eldering social roles appropriate to the expectations of society; that is, there are roles that are age-graded and that are typical of this part of the life span. Patterns of dress and speech are expected of persons of different ages in a society, and the social status accorded to individuals also differs at different ages. To these two processes, one should add psychological aging, called geronting. This is defined by the self-regulation the individual exercises, in a field of forces, by making decisions and choices in adapting to the processes of senescing and eldering. How we grow up and grow old is never an exclusive product of any single set of determinants. It is a consequence of our phylogenetic background, our unique individual heredity, the physical and social environments in which these genetic predispositions are expressed, and, for complex mammals like man, the effects of thinking and choice.

**TYPES OF AGE**

It is relevant to quote the Oxford English Dictionary's (1970) definition of "age," as follows: "The whole duration of the life or existence of any being or thing; the ordinary duration of life." Likewise, "aged" is defined as "having lived or existed long; of advanced age; old."

The definition of "aging" is simply "becoming old" or "becoming aged, showing signs of advancing age." However, in keeping with the previous differentiation of three types of aging, biological (senescence), sociological (eldering), and behavioral (geronting), it is useful to refer to three types of age rather than to one.

If one is aging, then one is moving from an earlier point in time to some later point in time. The biological age of an individual can be defined as the individual's present position with respect to his potential life span. Thus, an individual's biological age may be younger or older than his chronological age. The assessment of biological age would encompass measures of the functional capacities of vital or life-limiting organ systems. Presumably the vital organ systems lose their capacity for self-regulation and adaptive change with age so that the probability of dying increases with age.

The social age of an individual refers to his roles and habits with respect to other members of the society of which he is a part. An individual may be older or younger depending on the extent to which he shows the age-graded behavior expected of him by his particular society or culture. The measurement of social age would involve such aspects as the individual's type of dress, language habits, and social deference to others in leadership positions. Social age here is presumed to result from the dynamic process of eldering, which is the individual's course of life through the social institutions of which the individual is a member.

Psychological age refers to the behavioral capacities of individuals to adapt to changing environmental demands. Thus, just as one may be older or younger than one's chronological age, in both a biological and a social sense, one may also be older or younger psychologically. Clearly psychological age is influenced by the biological and social factors, but the concept goes further in that it involves the use of adaptive capacities of memory, learning, intelligence, skills, feelings, motivations, and emotions for exercising behavioral control or self-regulation. Survival and appropriate functioning in an environment requires a dynamic equilibrium in which the individual must con-
continually adapt to the physical and social environments and also to his own physical state.

Botwinick has discussed the question of just which individuals in our society are to be considered aged. Definitions of aging and age will continue to change as we gain knowledge. He quotes Havighurst's suggestion that as retirement changes and the nature of work changes, old age will be defined less and less in relation to work than to a broad concept of social competence (see Havighurst, 1957). Social competence is thought to be relatively independent of biological functioning although not at the extremes of disability.

Over a broad range of environmental and physiological conditions, it may be expected that there will be a high degree of independence of the three ages of man—biological age, psychological age, and social age. It is probably only at the extreme boundary conditions of the relevant variables that these ages are highly related.

In the nineteen-forties Cowdry wrote: "A general theory of aging is very difficult, if not impossible, to formulate at the present time since the rate and expression of age vary widely in different organisms; some plants, protozoa and insects, for example, do not exhibit the usual sequence of changes nor undergo what is called senescence." (Cowdry, 1942, p. xv.) There is still no general theory of aging, and certainly none that would be acceptable to psychologists. One almost senses that there has been little pressure to stimulate the intellectual endeavor required to produce a unifying theory that would explain how behavior becomes organized or changes over time. Thus, the psychology of aging appears to be a collection of concepts and hypotheses that do no more than explain limited aspects of behavior. No matter how broad or narrow the theoretical issues, however, it will always be true that the use of the term aging or age implies relationships with time. For this reason, some discussion of the nature of time as a variable is in order.

THE NATURE OF TIME

What makes a theory dynamic in its relationship to time? Development and aging clearly refer to changes over time. Theoretical statements about development, like the big bang theory of the origin of the universe or the theory of evolution, clearly imply a pattern of change with time.

The basic subject matter of any science is the recurrence of phenomena. Another way of saying this is that science consists of the observation and explanation of regularly occurring events. In the case of astronomy, observers over the centuries became sensitive to the daily recurrence of patterns in the position of stars and planets as well as the annual cycles of patterns. As the observations of the regularities became communicable, observers began to detect recurring phenomena that had cycle times of longer than one year as well as slower drifts. Clearly to be separated are the observed data and regularities of recurring phenomena in the solar system and the explanations that have been offered to account for the regularities. These range from the early attribution of events to demonic forces to more recent explanations offered in the traditions of natural science that implicate atoms and molecules and forces of attraction.

Time is always involved in any explanation, an explanation being a statement about how things come about. Explanations deal in causal sequences; a cause can occur only before an outcome. Without a notion of time, explanation in a contemporary or scientific sense could not take place. However, it might be pointed out that most explanations of psychologists deal with events over short periods of time. Some experimental psychologists may even object to the use of the term aging, since they believe that time cannot cause anything and, therefore, one cannot have a science based on the organization of events in terms of time. This would seem to be an unduly restrictive idea if only for the fact that there are many time-related events in the nervous system. It seems to be excessively limiting of scientific inquiry and behavior to adhere blindly to a belief that since time does not cause anything there cannot be a science of aging.

The individual human life is a phenomenon of one cycle. Since the length of life of the observer, the course of the individual life, is not the same as that of the phenomenon, as in the case of astronomy, it is necessary to
build up observations of many cycles and pass them on to succeeding generations of observers. One may observe in the human life cycle slow drifts in secular changes in the length of life or in the age of puberty. Shorter cycles may also be observed, e.g., annual cycles, monthly cycles, daily cycles, and recurrent cycles within a single day. Recorded history suggests that while certain general characteristics of the course of the individual human life remain the same, there have been drifts toward an average longer life as well as a drift in the development of boys and girls such that they mature and become taller and heavier at an earlier age.

In some inorganic systems, the regularity of molecular change is so great that it can be used as a measure of time and as a standard for other time determinations. Explanations of evolution and the development of culture heavily involve the ordering of events in time. The dating of a piece of charcoal from the remains of a fire of a prehistoric human community, for example, or the dating of a bone, is a very fundamental piece of evidence for scientists. The development of the universe, the formation of our planetary system, the evolution of different forms of life on earth, the development and diffusion of culture, and the life cycles of individuals require a common basis in relation to time regarded as a variable.

Atomic changes can occur with such regularity that their appearance may be used to measure a time lapse. Changes occur in an organic body with time that result in the aging of tissues and the possibility of dating them after the organism has died. Much effort has been spent by anthropologists in dating bits of pottery, carvings, and skeletal remains to test the adequacies of explanations of the development of culture, in North America, for example. How the North American continent was settled, by whom and when, requires detailed measurements of the age of objects. Were there not regular shifts in the amino-acid composition of bone with time, it would be difficult to establish the dating of a skull, say. Concepts of the Stone Age, Bronze Age and Iron Age require the ability to measure time and establish sequence.

One of the most fundamental features of systems is that they possess directions in time. Individually, we appear to move unidirectionally forward in time from our origins. Our age as individuals is marked by our memories and by our "flesh and bones." Expressed in other words, our age is marked by changes in our hardware as well as in our software—both being involved in the organization of thought, emotions, and actions. Schimmar and Stewman have pointed out (1978) that psychological and social duration may not be the same even with the same elapsed chronological duration.

The concept of aging in the general sense implies that if the organism moves forward in time, it has an average time in terms of the system as a whole. Presumably the age of subsystems can differ from the average of the whole. Reichenbach and Mathers (1959) pointed out that time direction in a large system can be different from that in its subsystems; that is, a large system may be moving forward in time, but there may be a subsystem which may be growing "younger" at the same time that other subsystems are growing "older." Thus one might attempt to describe an individual in terms of the mean biological age of the organs, e.g., the nervous system, heart, skin, endocrine glands, etc. Some cells of the body can regenerate without regard to age, such as the liver. During a period of regeneration the average age of the cell population of an organ might, in fact, be younger than it was at some earlier time. As a consequence, the functional capacity of the organ might also be greater at a later date than it was earlier.

Here the picture is one of a complex system moving forward in time that has a mean age that can be applied to the organism as a whole, yet with subsystem variation. Failure of a critical subsystem of the organism would limit the survival of the whole organism, but up to that moment the ages of the subsystems may not be in lockstep. Thus, knowing the average age of the subsystem or organism does not necessarily permit prediction of the probability of the organism's survival since the failure of only one system can limit the life of the whole. The life limiting organs of the body, the ones that seem to be potentially more important
in the survival of the whole, are those that are primarily composed of cells fixed at their present level of differentiation and whose tissues may no longer contain primitive precursor cells.

**FIXED CELLS**

Some organs are made up of fixed, postmitotic cells, which include neurons and the heart muscle cells. These cells lose their capacity early in life for further mitotic division and remain with the individual “from birth to death,” unless as individual cells they die earlier. The fact that the nervous system is composed in part of fixed cells makes it the major archival system of the body and thereby of great significance in aging.

Along with the nervous system, the immune system has a memory. It remembers organisms and molecules to which the organism has previously been exposed and which proved to be deleterious. The immune system, having recognized that it has met a certain foreign body before, mobilizes antibodies and cells to destroy it. Time is required to establish the immune defenses of the body, as shown by the high susceptibility of the newborn to infectious diseases. Late in life, the organism again becomes highly susceptible to disease. Burnet (1970a,b) has pointed out that aging of the organism is influenced by a progressive weakening of the immunological surveillance. Others have also pointed out the significance of aging to the immune system (Makindan, 1977).

Since the nervous system is not only essential to the organization of behavior but also to the regulation of vital physiological functions, it is one of the key organ systems for the study of aging. Its own aging will presumably not only be reflected in changes of behavior but also in a changing probability of survival. It is possible that the nervous system and the immune system are the two critical limiting systems for those individuals that survive early life events and diseases. The picture being drawn here is one of an organism consisting of a complex of subsystems, each of which has a somewhat independent course over time but retains the potential for limiting the life span of the total system. What is also suggested, however, is that these subsystems are hierarchically so organized that the failure of one may have a cascading effect relative to its position in the hierarchy. In particular, it is important to note that the subsystems may not interact until certain boundary conditions are exceeded. This is sometimes referred to as the “discontinuity” hypothesis (Birren, 1959). One of the consequences of this hypothesis is that biological, psychological, and social phenomena are expected to be increasingly correlated the nearer the end of life.

Not only is biological life often limited by the functional capacity of the aging nervous system, but the quality of life is limited as well. For behavioral scientists, aging has important dual aspects in that the cellular changes of the nervous system may determine behavioral capacities at the same time that behavior patterns may influence the rate and mode of the aging of cells in the nervous system. As the prime integrating organ system of the body, the nervous system plays an even more crucial role as an initiator and disseminator of influences to other organs. In particular, the control of the endocrine system and the pituitary gland is exercised by the neural and endocrine activity of the hypothalamus. Thus the menopause may be a primary phenomenon of central nervous system regulation, with peripheral changes in the ovary being secondary or tertiary to changes in the activity of the central nervous system (Finch, 1976). If, indeed, the menopause should be looked upon less as a primary manifestation of the aging of the ovary and more as a change in the aging of the central nervous system, the question becomes one of why the nervous system loses its capability with age for timing the release of hormones. This is one example of the fact that certain biological rhythms in complex vertebrates and lower organisms require the use of time for their description.

**TIME-DEPENDENT PROCESSES**

The menstrual cycle illustrates a rhythm of an organism that becomes disrupted over time because of the inability of the nervous system to maintain a periodic sequential release of
endocrines. In a hierarchical system, either a premature or a late release of hormones will not result in the proper expression of the primary phenomena. There are many natural rhythms of an organism such as temperature, metabolism, enzyme activity, and neural discharge. Short-term rhythms within a single day are termed circadian rhythms (Brown, 1972). The change in periodicity of these rhythms or spontaneous oscillations constitute part of the subject matter of aging.

According to Sampson and Jenner (1975), disorganization of the circadian rhythms can reduce mental efficiency to the extent of causing pathological states. Circadian rhythms may not only alter with age, but their function is so intimately tied with time that one may describe their outcomes as being virtually time-dependent.

In his review of the pineal gland, Axelrod (1974) summarized the experimental data that show that certain circadian rhythms in neurotransmitters can exercise an inhibitory effect on gonads. Especially important is the discovery that the enzyme (N-acetyltransferase) undergoes a circadian rhythm. The nucleus in the central nervous system regulating this rhythm appears to be in or near the suprachiasmatic nucleus in the hypothalamus. Such circadian rhythms are easier to observe than slower ones that occur over months or years. One of the more important biological clocks studied is one that has to do with the daily sleep–wakfulness cycle (Woodruff, this volume).

If there are subsystems of the organism that are hierarchically arranged, then perhaps we should think of an organism as consisting of a clock shop rather than as being controlled by one clock (Winfree, 1975). The study of phases in circadian and longer intervals and their experimental disruption phase appears to offer a methodological approach to experimental studies of aging.

In an earlier review of biological periodicities (Landau, 1959, p. 81), it was stated that “Time is inseparable from aging; it may be, therefore, useful in organizing our thoughts about aging to consider the role of time in some biological processes. Many processes are clocklike in their rhythmicities, while others have a characteristic duration. It may be said that most biological processes are appreciably modified by aging no matter in what sense the word is used.” The hypothesis of a declining effectiveness of the aging nervous system in timing regulatory functions is an important one, although perhaps psychologists have not given it serious attention as yet because it appears to deal with the hardware of the organism to the exclusion of the software of experience and learning. It is, however, precisely because such a point of view encourages study of both the hardware and the software resulting from environmental conditions that future experiments designed to study the control by the central nervous system over bodily rhythmic activity over the life span are necessary.

**AGE AS AN INDEX**

Some psychologists view time as merely an index to events. It should be pointed out, however, that if this were the only status of time as a variable, it would still be an important one. Without time as an organizing concept, data become meaningless, and it is possible that there is no single variable that is more powerful as an index for organizing data than chronological age.

In examining age differences in behavior, of course, other powerful indices are also used, for example, sex, socioeconomic status, and ethnicity. As with age, in none of them is it assumed that it is the index variable in itself that causes the behavior. In the case of socioeconomic status, it is presumably not, for example, the size of the bank account of the individual that is causing the behavior. Because age is such a powerful index, it will probably always be used to classify data while we are en route to explanations using variables other than the mere ages of individuals.

Birren and Renner (1977, p. 26) have said that, “In a rigorously experimental sense, age must be approached in research as a variable that ultimately must be eliminated.” This statement implies that as we approach a real understanding of why age groups differ, we will no longer use age as a variable. Presumably differences in behavior with age are associated with environmental causes, genetic causes, and individual processes.

Another source of confusion and unique individual, such as the size, form, and function of the aging, of the organism. Choices in behavior that occur between environmental and genetic background remains changing with time. It is important that places age in an explanatory variable.

The importance of time and individual decision, as with the discipline as variables being explained and repeated that all explain that. That is to say, outcomes, antecedents, or, in functional, independent variables are independently variables. Let us since to concurrently cause one another.

Holding constant the experiment reduces a number of criteria, but makes many associated experimental effects that in addition to the accumulation of changes that result from the events are determined by molecular properties, the interaction of protein with age (and/or age) is so intertwined that it cannot describe the system.

In the case of human events, we must know how old an organism lived. For purposes, we want to know whether it lived or late historically. What is the fact that the organism that is not real, time flows in one direction in terms as well as for the universe, and for those mechanisms backwards; it can only in there is the other question to flow forward. We can individual from the shifts composition in the box.
duration. It may be said that processes are appreciably no matter in what sense the hypothesis of a declining the aging nervous system function is an important hypothesis psychologists have not been as yet because it appears to be the hardware of the organism. The software of experimentalism. It is, however, precisely this view that encourages study of the environment and the software resulting in the individuals changing with time. It is partly this interaction that places age in an ambiguous position as an

explanatory variable.

The importance of genetics, environment, and individual decisions as variables shifts with the discipline and the kind of observations being explained. However, it must be repeated that all explanations involve time. That is to say, outcomes are consequences of antecedents, or, in functional terms, some dependent variables are a function of some independent variables. Logic itself involves time, since two concurrent processes cannot be causing one another.

Holding constant the age of animals in an experiment reduces a source of variance but must make many assumptions about the experimental effects that are obtained. In addition to the accumulation of irreversible changes that result from wear and tear, some events are determined by inherent atomic or molecular properties, such as the polymerization of protein with age. In such cases, time (and/or age) is so intimately involved that one cannot describe the system without its inclusion.

In the case of human beings, it is important to know how old an individual is and when he lived. For purposes of understanding, we want to know whether a person existed early or late historically. What gives age its importance is the fact that there are features of the organism that are not reversible. For example, time flows in one direction for the organism as well as for the universe. We can thus look for those mechanisms that act like the ratchet and cog of a watch to stop time from flowing backwards; it can only flow forwards, but there is the other question of what makes it flow forward. We can assign an age to an individual from the shifts that occur in amino composition in the bone with time.

The atomic clock is based upon the fact that known quantities of atoms disintegrate in a fixed period of time. Since the atoms that disintegrate do not reform, we are dealing with an irreversible process. In the case of the decay of radioactive atoms, the probability of any molecule disintegrating is constant, yet the proportion of molecules that have disintegrated is a function of elapsed time. Thus, probability and time are related for large numbers of atoms but not for single atoms. The portion surviving in a given population is a decreasing exponential function of age. In this sense, age does not enter the equation other than as "clock time."

Some lower animals exhibit an exponential type of survival, but in a strict sense the population doesn't show aging since the probability of survival is a constant. On the other hand, the aging of human populations does not occur in the same fashion because the probability of dying is not a constant; rather, it accelerates as a function of age, that is, the older the population, the increasingly higher the probability that individuals will not survive.

The association between atomic change and time is so close that one may alternate between using the ratio of two forms of atoms to determine the age of the sample and the use of the deterioration itself as a fundamental measure of elapsed time. Landau (1959, p. 113) pointed out that there are various kinds of biological time clocks: "If a function is perturbed by experimental manipulation, its temporal behavior gives information about the underlying mechanisms. A single time constant may be adequate to describe the process if the function simply returns to normal. However, the function may not return to its original state."

In the case of complex organisms, recovery from the effects of wear and tear is presumably not complete, and there is some irreversible residue as a consequence of an event. This is not unlike the learning process, in which the age of the subject becomes a necessary bit of information. Without such knowledge, it would be difficult to interpret not only some data about learning but about other aspects of human functioning. Another way of saying this is that there is much history involved in
the age of an organism, or, in the same vein, that to understand the outcomes of an experiment one must know the organism’s history.

Time then has many uses—in the measurement of elapsed time as an important descriptive variable in explanation, as a dependent variable that requires explanation, or as an independent variable in the explanation of other phenomena. It is these different applications and layers of meaning in the concept of time and age that give rise to confusion in their scientific status as an area of scientific study.

In comparing the behavior of young and old individuals, many differences are immediately observable. Some of the differences may be attributed to a species pattern of biological change—that is, senescing; others to a social environmental process of change—that is, eldering; still others to a process of decision-making on the part of the individual—that is, geronting. The study of age differences is not unlike that of the differences that may be found in public-opinion surveys in which the data are divided by sex, socio-economic status, and occupation.

Birren and Renner (1977, p. 4) pointed out that age change in behavior is presumably not an exclusively biological, environmental, or social phenomenon. Their definition of aging is as follows: “...aging refers to the regular changes that occur in mature genetically representative organisms living under representative environmental conditions as they advance in chronological age” (ibid, p. 4).

Since studies of age differences tend to consider the individual as a passive entity, many views of age differences in behavior ascribe them to: (1) disuse, (2) wear and tear, or (3) selective reinforcement by the environment. The latter would in simple terms state that “If I act like an old person, I have been reinforced by society to act like an old person.”

An ontogenetic theory of aging, on the other hand, makes the species more active as a proactive, causal agent in the changes in behavior resulting from choices and decisions. In turn, however, this probably reflects an interaction between the options provided by the environment and the values acquired in a social environment as well as the results of reasoning and choice.

The need for theory in the psychology of aging is accentuated by the increased amount of data. Salthouse (1983, p. 39) pointed out that “facts are accumulating at a rapidly accelerating pace in the field of adult cognition, and unless theoretical frameworks are available to organize these facts they may become overwhelming and consequently be ignored because they are impossible to assimilate.”

One of the common ways of handling theoretical issues in the psychology of aging is to use theory borrowed from another area of psychology that attempted to explain how behavior was organized in the constant aged subject, that is, the young adult. In this case, adding age as a variable results in consideration of age differences. The problem that arises, however, is that the variables considered in explaining the organization of behavior in the young adult may not be the ones involved in giving rise to differences between the young and the old organism. Salthouse pointed out that there is a difference between trying to explain age differences and age changes. Age differences can arise from many uncatalogued reasons. Age changes are the shifts in the organization of behavior that occur with age, some of them undoubtedly typical of the way the species in question ages.

THE EVOLUTION OF AGING

Various animals have characteristic lengths of life of their species. It is assumed that the species patterns of aging have become established in the slow time of biological evolution. The comparative approach examines the similarities of aging in mankind in comparison with other species. Basically, this approach attempts to find out what the processes of human aging have in common with the aging of other species. Presumably the pattern of aging should show a phylogenetic ordering, and the aging of mankind should be similar to that of the species closest to mankind phylogenetically. Other vertebrates, and particular primates, should show morphological, biochemical, and behavioral changes with age similar to those of human beings to the extent to which there is a common evolutionary basis for the organization of late life change.

A comparative approach to the study of aging attempts to discover similarities in the mechanisms of aging among different species. O’Connor (1957) stated that the study of aging is the central theme of the comparative approach to the study of aging among species that are not closely related. O’Connor (1957, p. 115) stated that animals develop in the basic processes and certain empirical conclusions can be reached about the evolved commonalities or adjacencies of species that share, intraspecies differences (but not interspecies differences).

A second approach to the study of aging is to analyze aging within the species. It is particularly important for psychology to examine similarities among species within the species of interest in terms of the various characteristics across species approaches.

Confusion can arise when attempting to distinguish whether a species is an intra- or inter-specific aging. Psychology tends to focus on differences within the species, whereas psychology tends to look at commonalities among species. Birren (1964) proposed that aging could be divided into two types: accident or wear-and-tear, and counter-possessing, meaning the ability to resist or be resistant to wear-and-tear. Ratios in longevity as a species vary among species in the environment. Early research on aging seemed to regard the species as one that could exist in the old animal.

A theory of the evolution of aging attempts to explain the selection of traits in species displays long after reproduction and presumably selection of traits, characteristics, and successful reproduction by the ones that are not selected. Until recently it was thought that characteristics of late life (the age of reproduction) were selected characteristics of reproduction, selection, and successful reproduction, as a result of the characteristics of late life have been directly selec...
aging attempts to discover the phylogenetic similarities in the mechanisms of aging. An early symposium sponsored by the CIBA Foundation was devoted to the methodology of the study of aging (see Wolstenholme and O'Connor, 1957). In emphasizing the value of a comparative approach to aging, Muhlböck (1957, p. 115) stated, "It can be presumed that animals do not differ from man in the basic processes of aging, so that valid conclusions can be reached." In addition to the evolved common patterns of aging that adjacent species share, there are nevertheless intraspecies differences (Finch and Hayflick, 1977).

A second approach to the study of human aging is to analyze individual differences within the species. It is, in fact, more common for psychology to examine individual differences within the species than to analyze commonalities across species in a comparative approach.

Confusion can arise if investigators fail to distinguish whether their dependent variable is an intra- or inter-species characteristic of aging. Psychology tends to examine individual differences within the species, and biology tends to look at common mechanisms across species. Birren (1964) pointed out that theories of aging could be divided into three types: accident or wear-and-tear theories, genetic theories, and counterpart theories. All three possess credibility, depending upon the nature of the dependent variable being explained. An accident or wear-and-tear theory looks at differences in longevity as a function of variations in the environment. Earlier theorizing about aging seemed to regard it as implausible that there could exist an organized process of change in the old animal.

A theory of the evolution of aging must explain the selection of the characteristics a species displays long after the time of reproduction and presumably beyond the pressures of selection. Characteristics that favor survival and successful reproduction in early life presumably will be the ones that are perpetuated. Until recently it was thought that since the characteristics of late life appear so long after the age of reproduction, late life (postreproductive) characteristics of a species could not have been directly selected. However, the evidence is that species do maintain their relative order of longevity despite environmental variations. Also, individual differences within the human species are related to the longevity of previous generations, e.g., grandparents. Thus the length of life has order between species and within species, but how it arises and is organized is the scientific question. The counterpart theory suggests that regularly appearing characteristics of late life (including longevity) must be an expression of traits that were selected at the time of reproduction. "It describes a pathway through which order could have been introduced into the changes in the old, or post reproductive animal. Obviously, beyond the order implied by counterpart theory, events occur that superimpose their consequences on the organisms in the above view have some long term programming" (Birren, 1964, p. 74).

In this view, some of the regular changes that appear in old animals are a counterpart of the early developmental characteristics that were selected. It should be pointed out that aging in this context is not simply a mirror image of early-life processes. Thus a late-life disability might be, in fact, a consequence of selection of some earlier favorable traits. Smith made this point rather well, as follows: "A high blood pressure may contribute to death from cardiac disease in old age, but cannot have consistently adverse effects on fitness, since if a high blood pressure were uniformly disadvantageous, natural selection would reduce the need level in the population. It is, therefore, probable that the deleterious effects of high blood pressure in old age are counterbalanced by advantages, perhaps earlier in life, natural selection maintaining the mean arterial pressure in the population at an optimal value" (Smith, 1957, p. 121).

Although programming of late-life characteristics on a genetic basis, including that of longevity, could emerge on the basis of counterpart selection, including behavioral selection, how much organization of late-life change is genetically programmed open to question. It is plausible that the genetic program of aging may not be as well-organized or specific as that of development. The further that one moves from the age of reproduction, the less precise should be the genetic control
over characteristics of the organism. In this sense, there is likely a precession of biologically favorable survival traits appearing early in life and a recession of unfavorable traits in later life, the latter being more difficult to remove by selective pressures. The appearance of a variety of genetic diseases of late life would fit such a view in that the longer the members of a species live, the more likely they will experience a deleterious disease difficult to eliminate by selection.

It should be pointed out that behavioral factors can be involved in the counterpart process, that is, the ordering of late-life events could arise via natural selection of long-lived and intelligent persons. Although individual differences in longevity do not appear until long after reproduction has been completed, offspring whose parents survived a long time are themselves more favored to survive in the environment. The reasoning might be extended further to preindustrial societies in which individuals who lived a long time were more likely to accumulate wealth and provide more favorable conditions for the survival of their offspring, e.g., food and protection. In this manner, genetic selection for longevity could be accompanied by favorable late-life behavioral traits. In a related manner, those individuals who show great capacity for learning, retention of information, and wisdom in late life would be more likely to provide favorable environmental circumstances for their offspring and tribe.

The probability of survival of a tribe presumably would be higher if its elders or leaders lived a long time and exercised the quality of wisdom. In contrast, the accumulation of large numbers of disabled older persons in competition for territory and food would make a tribe unfavorable for survival. It would be unproductive to sketch the various circumstances that might lead to selective pressures for long-lived individuals who show behavioral characteristics favorable to the survival of their family and tribe. It is only necessary to make the point that natural selection for longevity may be coupled with favorable late-life behavioral characteristics.

The survival of complex organisms in wild or natural environments depends upon effective behavior. In this sense, behavioral selection may determine genetic characteristics. Since selection always takes place in a particular environment, the exposure of animals, including human beings, to new and unfamiliar environments may result in the appearance of characteristics never seen before. These might appear, for example, in the aging of individuals who were exposed to a new and unfamiliar environment, e.g., in the weightlessness conditions of space flight. Not all of the responses of organisms to a new environment are predictable, and genetic-environmental interactions can be profound. For example, Henry, Meehan, and Stevens (1967) demonstrated that inbred mice will or will not show a rise in blood pressure with age depending upon the social structure and interaction patterns in a colony. Perhaps, then, the commonly observed rise in blood pressure in late life is less an expression of a genetic characteristic than it is a manifestation of a genetic-environmental interaction, genetic factors presumably setting the range within which environmental influences can have effect. Interaction between genetic characteristics and long-term environments may lead to specialization, disuse, and loss of function. Such selective differentiation presumably led to the birds that can no longer fly, such as the kiwi or the ostrich.

Early-life behavior and experience should be expected to comprise the behavioral repertoire of older adults but not in terms of a direct and literal translation. In terms of the counterpart theory, one should not expect an isomorphism between characteristics of early and late life. From the counterpart point of view, one should not expect a simple translation of early-life behavioral characteristics and experience as implied by earlier psychoanalytic points of view. In fact, what is needed is a scientific metaphor that can capture the transformation of early-life characteristics into late-life ones. Perhaps the image of a projection of early-life experience much like the projection of moving pictures onto a current scene has some promise of being extended to carry the thought that while the repertory of experience is carried forward in time, the nature of the projector and the screen onto which it is project-
sence, behavioral selection genetic characteristics. It takes place in a particular exposure of animals, infants, to new and unfamiliar stimuli in the appearance it had been seen before. These animals, in the aging of the more to a new and different, e.g., in the weightless environment. Not all of the studies of the new environment or genetic-environment interactions. For example, Stevens (1967) demonstrated that certain species will or will not show increased aggression with age depending on the species and interaction pattern. Perhaps, then, the changes in blood pressure in late adulthood is a manifestation of a genetic-environment interaction, genetic factors interacting with the environment which influences the expression of these factors. Such a phenomenon is common among species such as the kiwi and some birds.

In terms of the counterpoint, one cannot expect an isomorphic relationship between early and late life. From a different perspective, one may be able to look at the early and late life characteristics and experience from different points of view. What is needed is a scientific approach to understand the transformation of early life characteristics into late-life ones. This is akin to the projection of early life onto a current scene has some tendency to carry the thought process. The theory of experience is car- ing, the nature of the process onto which it is project-

AGING IN HUMAN SOCIETY

Previously the point was made that the way we age is a function of the way we develop, i.e., aging is a counterpart of development, although our potential for senescence is modified by the physical and social environments in which the organisms grow up and grow old. For most persons, there is a change with age in the way they dress, the way they speak, and the ways in which they relate to other persons. Since our nervous systems are in a large part programmed by our experiences in our social environments, shifts in our behavior reflect the expectations or age norms of our society. The expression “act your age” usually implies you are acting immaturerly and that you should act more appropriately for someone of your age.

Culture is the organization of social status, social roles, and social rituals; it may be regarded as the “DNA” of society. Variables of culture influence the distribution of status, prestige, power, and resources. One would argue that all societies are to some extent stratified by age as well as by social class and sex. Ragan and Wales (1980, p. 386) pointed out that age stratification is a complex social system in which from some points of view the aged are disadvantaged, but in other ways, advantaged. The term ageism has been used to refer to the negative stereotypes applied to older persons. In work, old people may be disadvantaged by being pushed out of occupational roles and thereby lose income. They do, however, have a great deal more leisure time available to them. Usually in American society, older persons occupy a lower status since on average they have lower status in work and income. In addition to economic and work roles, the family, religious organizations, and other groups provide for different forms of involvement in accordance with age, some of which are tied to the reproductive cycle of being child, parent, and grandparent. Underlying the roles assigned to people of different ages is the shifting belief structure of society that tends to change the function of older persons.

Interacting with these secular changes or drifts in customs of society related to age is the life course of the individual. Because of this interaction, the attitudes that have been early engendered may be in conflict with the changing expectations of society when one grows up. There are thus three or more “times” involved: One is the slow time of biological evolution, a second is the somewhat faster time of cultural or societal change, and the third is the still faster time of the life cycle of the individual. Clearly, one cannot only use length of life as the dependent variable in relation to the adaptations, coping, and adjustments of the individual to growing old in a particular culture.

Changes in the age of retirement and the age at which social security benefits become available are a function of the values of society and the economic resources available in periods of recession, inflation, or economic growth. Some aspects of the stratification of age and society are determined by informal norms and rules that are passed on from generation to generation and may vary between social classes.

The development of positive and negative views of old age are also influenced by the family (Bengtson and Casteels, 1980). In America, young adults regard old adults as being of lower status and prestige. Having a negative image of old age, young adults therefore have a negative anticipation of growing old. Older adults in American society usually hold a more favorable view of their life circumstances than do young adults (Birren & Renner, 1980).

Studies have been made about growing up and growing old in cultures other than the United States. In comparing the U.S. with other countries, the diversity in the background of its population should be kept in mind. The U.S. is populated by many immigrant groups. Usually in other countries of
the world, different racial, ethnic, and language groups tend to live in more distinctly separate regions, a fact that to some extent preserves their integrity. In a pluralistic society like ours, individual differences in aging are far more common.

Theories of aging versus psychological theories employing age differences

The psychology of aging is concerned with differences in behavior with age, changes in behavior with age, and patterns of behavior shown by persons of different age in different periods of time. These different points of view treat age as a variable in different manners. A study of the shift in attitudes of older persons from Victorian times to the present would conceive of historical time in a different manner than a biographer would in describing the changes in an individual life or a biologist would in examining species of animals in an attempt to identify the universal patterns of transformation with age.

It has already been pointed out that much of the contemporary psychology of aging is a collection of segments of knowledge (Birren, Cunningham, and Yamamoto, 1983). This implies that most theories in the psychology of aging are actually microtheories; they do not embrace large amounts of data from different domains of behavior. This in turn implies that different levels of explanation are used by investigators and that their explanatory positions are very close to their observed data with little reference to the kind of comprehensive concepts that would be involved in viewing man as a constantly transforming biological system moving forward in time with interactions within his own organism as well as with his social and physical environment.

Operational Issues in Studying Age

Most studies of aging utilize chronological age as a primary variable of interest in spite of considerable dissatisfaction with this practice, both conceptually and in terms of methodological implications. Clearly, the scientific study of aging requires considerably greater complexity of both concept and method than was believed necessary in the recent past. The main purpose of this section is to explore some alternatives to the employment of chronological age.

Studies of aging may be classified according to the manner in which they make use of the aging variable. There are two major approaches; from a developmental perspective, these may be characterized as "static" or "dynamic." In the "developmentally static approach," the researcher may select a particular age range or period of development to investigate and then proceed to develop theoretical statements or principles that characterize this particular age group. Here the age variable is employed primarily to identify the boundaries of the domain of study. In contrast, the "developmentally dynamic approach" seeks to develop theories or principles which characterize the process of change, that is to say, how the organism develops and what characterizes such change, how it occurs, etc. In static studies, the role of the age variable is not a difficult one, given the minor function which it plays. In contrast, the age variable is critical in studies that are developmentally dynamic.

Not only is the role of the age variable crucial in dynamic studies of development, but the manner in which age should be operationalized has been the source of considerable discussion and even heated debate. It is now generally recognized that the cross-sectional approach suffers from the possible confounding of nondevelopmental, cohort influences, which may limit the degree of certainty of an age interpretation of behavioral differences identified by this design. The longitudinal method, although conceptually sounder, suffers from a variety of limitations as well. In addition to its substantially increased costs and demands on time, selective attrition as well as time-related cultural events limit its interpretability. Finally, various sequential strategies of data structuring, which involve combinations of the simpler, basic descriptive designs, do not escape from the limitations of their constituent components and thus yield a situation that does not allow for unambiguous conclusions.

In addition to the debated methods (Hammack, 1978), there is an underlying concern about either age or age-related variables. Manifestations of human behavior and whose accumulation with time, but rather the manifestations themselves, the differences that are of interest of research in the nervous system, changes that are not manifested by chronological age, there seem to be two.

The first is to accept the surrogates variable (e.g., age-related conglomeration, time, or any other variable that can be associated with the phenomena of aging) and to attempt to identify the phenomenon of aging and either use or supplement chronological age, or replace chronological age, or replace chronological age, or replace chronological age.

This approach is directly from the traditional way of looking at human behavior and, therefore, continues to be popular. It is commonly referred to as the "cumulative damage" model, a model that was first proposed in the 1950s and has been influential in the study of aging. It is based on the idea that aging is a gradual accumulation of damage to the body as a result of environmental, social, and biological factors. This model suggests that the progression of aging is a result of the accumulation of these damages over time, and that the rate of aging is determined by the rate of accumulation of these damages.

Although chronological age is certainly a useful variable for grouping individuals into age categories and for making comparisons between individuals within these categories, it does not fully capture the complexity of aging. For example, two individuals may have the same chronological age but may have different experiences and health statuses, leading to different patterns of aging. Therefore, it is important to consider other variables that may influence the aging process, such as genetic factors, lifestyle, and environmental conditions.

The biological model of aging is based on the idea that aging is a result of the biological processes of the body, such as the accumulation of cellular damage, the decline in the function of organs, and the loss of the ability to repair and regenerate tissues. This model suggests that aging is a progressive and predictable process that is influenced by factors such as genetic predispositions, environmental exposures, and lifestyle choices. It is also important to note that aging is not a linear process, but rather a complex and multifactorial one, influenced by a variety of factors that interact in different ways.

In conclusion, the study of aging requires a multidisciplinary approach that considers a wide range of factors, including biological, psychological, and social factors. It is important to recognize the complexity of the aging process and to develop methods that allow for a more nuanced understanding of aging. This may include using alternative variables to measure aging, such as functional status, cognitive performance, or physical health, as well as incorporating a lifespan perspective that considers the interactions between these factors over time.
In addition to these widely discussed and debated methodological issues (Botwinick, 1978), there is also a conceptual problem. Time per se probably does not cause anything directly. What most researchers are really interested in are the changes that may occur in the nervous system or the experimental changes that are recorded there. The ultimate interest of researchers is not in the passage of time, but rather the neural and behavioral manifestations that are influenced over time and whose accumulations are crudely indexed by chronological age. Once this is recognized, there seem to be two obvious courses to follow. The first is to accept chronological age as a surrogate variable that stands for an undifferentiated conglomeration of influences and therefore recognizes chronological age as a primitive, although relatively useful, index variable that can be employed to represent the phenomena of aging. The second approach is to attempt to identify specific aspects of aging and either use these constructs to supplement chronological age, or more ambitiously, to replace chronological age.

This approach is a substantial departure from the traditional ways of studying aging and behavior, but the idea itself is hardly new. It is commonly remarked today (as it has been in the past) that a person seems old and tired for his years, or, alternatively, that it is hard to believe that a certain person is really as old as he actually is. Concretely, many people are not ready to retire from their jobs at age 65 since they are still vigorous and effective. Others may not last until age 65 and may have to retire at an earlier age.

Although chronological age is almost certainly going to remain the “meat and potatoes” variable for the bulk of aging research, attempts to augment or replace it by more specific constructs that are related to intrinsic aging processes are likely to increase in both number and sophistication in the years to come. At the very least, there is considerable potential for such research to inform and amplify results from more traditional research based on chronological age. It is not likely, and perhaps not even desirable, that such new approaches replace the traditional kind of study, but it is both desirable and likely that such new kinds of studies augment and perhaps, in some cases, enhance our theoretical understanding of the aging process.

The idea of alternative or supplementary representations of the age variable is not really a new one. Quite a few years ago, Speith (1964) considered the relationship between cognitive functioning, aging, and cardiovascular disease. His line of research has been continued by other researchers (e.g., Wilkie and Eis dorfer, 1971; Light, 1978; Elias, 1980). There are other examples as well. Recent longitudinal work (Mossey and Shapiro, 1982) has shown that subjective health indicators have significant validity for predicting mortality and supplement, in an important way, more objective indicators of health status. A number of investigators in behavioral research have provided a conceptual umbrella by introducing a conceptual distinction between primary (normal, disease-free) aging versus secondary (disease-related) aging. In biology, this distinction is commonly made and labeled as endogenous and exogenous aspects of aging. It is emphasized that the employment of chronological age implicitly involves a mixing of these influences.

Another approach to this problem is illustrated by the various studies of “functional age.” Basically, such studies have usually involved the identification of variables believed to be related to age. After data have been gathered on a large sample of individuals of widely varying age, multivariate data analysis (usually multiple regression) is employed to evaluate which set of variables best predict chronological age. The primary purpose of this exercise is usually to attempt to develop a “yardstick” of functional age that will facilitate personnel decisions in industry, particularly retirement (e.g., Dirken, 1972). At an empirical level, such investigations have been very successful in that variable sets have been identified that predict a truly substantial amount of variance in chronological age—sometimes over 60 percent.

Functional age researchers have varied to the extent that they hypothesize a unitary aging process, on the one hand, or prefer to assume multiple-aging processes and various combinations of variables, each of which may
be optimally employed for different situations or against different criteria.

Dirken (1972) presented the issue quite forcefully when he said that the assumption underlying this approach was either that there is a unitary force of aging or that the various forces of aging could reasonably be considered as a higher order construct. Dirken found that chronological age could very effectively be predicted from a variety of functional measures (vital capacity, grip strength, and various perceptual and cognitive abilities). His multiple correlation between chronological age and a composite functional age produced a score of 0.87. This is an impressive level of prediction.

Heron and Chown (1967) took a more cautious stance, suggesting that some veteran researchers are taken aback by the idea of a functional age and that there may be different equations for different situations or occupational categories. They explicitly disavowed the "general aging" construct approach. Nevertheless, along with Dirken, they found high correlations between a functional age composite and chronological age.

The progress of the concept of functional age has not all been clear sailing. The idea was pointedly criticized by Costa and McRae (1980). The conceptual basis for the commonest empirical approach was severely criticized. The most common approach is to employ multiple-regression techniques to predict chronological age. If the ultimate criterion is chronological age, why not use that variable to begin with since it is easily obtained, readily verifiable, and simple to use and understand?

These authors also pointed out some unexpected outcomes of using regression procedures. Data from the Baltimore longitudinal study were presented that cast doubt on some possible implications of the functional age concept. Nevertheless, the implicit restriction in range (compared to the wider age span in both the two studies discussed here) as well as other limitations acknowledged by Costa and McRae suggest that the idea of functional age be more searchingly examined, rather than discarded. It also seems clear that greater conceptual input and construct structuring would be useful since doubts have been expressed as to whether functional age has any real advantages, given the conceptual and empirical limitations noted above.

Interesting in this regard are the data of Heron and Chown, which have been reanalyzed (by the second author) with regard to the issue of predictability. The focus of attention here is the relative predictability of two aspects of intellectual functioning: Figural Reasoning (a composite of the Raven Progressive Matrices, Perceptual Mazes, and Trail Making) and Perceptual Speed (a variation on the Digit Symbol subtest of the WAIS). These abilities are widely believed to be relatively sensitive to the age variable. [See Heron and Dirken (1967) for a more detailed description.] It was found that a functional age measure (a composite of forced expiratory volume, grip strength, and hearing loss) better predicted two intellectual abilities than did chronological age in a sample of 300 males ranging in age from 20 to 80. Although the gains in predictability were not substantial, it seems clear that a functional age construct may have empirical advantages in predictability as compared with chronological age.

Clearly, such results justify further consideration of the functional age idea. The approach of using chronological age as a criterion and employing multiple-regression procedures to develop composite weights, though undoubtedly necessary as a preliminary phase, is nevertheless overly empirical and requires further conceptual development.

There is a set of concepts about aging that is already available in the existing literature and can be brought to bear in this context. First, there is the conceptual distinction, widely accepted by behavioral gerontologists and well documented in the empirical literature, between primary aging and secondary aging, a distinction analogous to what biologists call intrinsic and extrinsic aspects of aging. This concept distinguishes between normal, disease-free aging, on the one hand, and disease-related pathological decline, on the other. Furthermore, the concept of terminal decline (Siegler, et al., 1980) has also been used to designate possible changes that may occur shortly before death to within several years of it. A number of workers in the field have suggested that a different magnitude even of a different kind related to primary aging is also apparent that style (stress, pace of abuse, exercise, mobility and probably many for altering the course of secondary and primary versus Type B) may be aging or the expiring.

Although the fact is confirmed, the concept of other aspects of aging in research in the field example, most empiri screen their subjects that their subjects are "healthy-old". The stated, underdocumented, is that species-specific, norm for which disease process extraneous nuisance variables cheerfully ignored chronic disease ever being elderly. Thus, although aging is at the heart of efforts in behavioral the concept of secondary aging is of limited significance. This is preamble to some empirical discussion.

One possible approach, a primary aging construct, variables known to be obviously dependent. These variables would be slow, gradual characteristics, either a genetic aging or reproductive wear-and-tear. Examples of such variables might include vital capacity, the heart, or other indicators of function.

Disease-related aging might involve a variety of factors influencing brain function. For example in the empiri...
have suggested that these changes may be of a different magnitude, timing, and perhaps even of a different nature, than the changes related to primary and secondary aging. It is also apparent that different aspects of life style (stress, pace of life, nutrition, substance abuse, exercise, morale, socioeconomic status, and probably many others) have the potential for altering the course and perhaps the rate of secondary and primary aging. Furthermore, differing personality patterns (e.g., Type A versus Type B) may alter the course of primary aging or the expression of secondary aging.

Although the fact is often not explicitly affirmed, the concept of primary aging (versus other aspects of aging) is fundamental to current research in the psychology of aging. For example, most empirical researchers either screen their subjects for health status or report that their subjects are "healthy and community-dwelling." The assumption, often unstated, undocumented, or inadequately operationalized, is that the area of interest is a species-specific, normative process of aging, for which disease processes are taken to be extraneous nuisance variables. This assumption cheerfully ignores the high prevalence of chronic disease even in the community-dwelling elderly. Thus, although the idea of primary aging is at the heart of most current empirical efforts in behavioral gerontology, the factor of secondary aging is of considerable potential significance. This is particularly true if generalization of these empirical findings to the elderly population is desired.

One possible approach to operationalizing a primary aging construct would be to identify variables known to be sensitive to age but not obviously dependent on a disease process. These variables would plausibly be related to the slow, gradual changes believed to reflect either a genetic aging program or a cellular, reproductive wear-and-tear program, or both. Examples of such variables from other studies might include vital capacity, grip strength, or other indicators of functional capacity.

Disease-related aging or secondary aging might involve a variety of chronic conditions influencing brain function. The commonest example in the empirical literature is cardiovascular disease, with indicators such as blood pressure, physician ratings, subject ratings, or health records. Naturally, other diseases (cancer, for example) are likely to be important as well. Several possible levels of explanation are possible, but it should not be overlooked that the level itself may have important implications for measurement. In positing a global health construct, for example, it would probably be necessary to rely on physical or objective global ratings. One could also opt for the measurement of the larger and critical physiological systems, for example, the cerebrovascular system, the immune system, and the hypothalamic system. Although there would be some loss in parsimony of means, there is apt to be a gain in precision of measurement. A still more analytical approach would be to attempt to evaluate specific disease/health dimensions for all of the major disease processes that might plausibly influence cognitive functioning or other behavioral variables of interest. At this level, considerable precision of measurement would be possible, and physician ratings, subjective ratings (see LaRue, et al., 1979), physiological measurements, and also laboratory tests might all be profitably deployed. It is likely that the various levels of explanation may be sufficiently interrelated to justify a hierarchical structure, from global to analytical levels, but the authors are not aware of any published study that focuses primarily on this problem.

A third major aspect of the aging process that may be abstracted from the existing literature concerns the period of approaching death, which is sometimes referred to as "negative age." One idea often discussed is terminal decline. The idea of terminal decline is that some individuals may go through a period of behavioral change that may be larger and/or qualitatively different from normal age changes in behavior. This period of time may range from months to years but is characterized by cognitive and social "slipping"—that is, a deterioration of previous levels of performance that brings about not only greater losses than expected in age-sensitive variables, but losses in variables that are usually regarded as age-insensitive. This phenomenon was first reported by Kleemeier (1962) and has been sup-
ported by various results since (see Siegler, 1975).

Another concept, which in some ways is the converse of terminal decline, is familial longevity. Clearly, some individuals have greater longevity than others. This particular factor of aging is believed to be inherited and thus widely regarded as having a genetic basis. Such biological vigor seems to manifest itself in longer stability and higher levels of performance. It is likely that a concept like vigor (Jalavisto, et al., 1964) would be useful as one factor of aging, though it is likely that it will be found to be strongly (if inversely) related to terminal decline.

So far, several aspects of aging have been reviewed that are not only easily conceptualized but implicitly utilized in much current research. It would appear to be an important item on the research agenda for the next decade to make their usage explicit so that they can be explicitly evaluated.

Recent conceptual and technical advances in multivariate data analysis (e.g., Joreskog and Sorbom, 1978) have provided a statistical basis for models that explicitly consider various aspects of aging. Of particular importance is the method of linear structural equation modeling. Recently published programs put this method within the grasp of nonspecialist who nevertheless have some training in multivariate statistics. They allow for the postulation and empirical testing of explicit models that incorporate different aging constructs.

An example is the Cascade Model, which posits a particular pattern of aging constructs and seeks to explain several aspects of intellectual functioning. The model is portrayed in Figure 1. On the left side of the figure are three facets of aging already discussed: primary, secondary, and tertiary aging. On the right side of the figure are three well-replicated classes of intellectual functioning, referred to as Verbal Comprehension, Reasoning, and Perceptual Speed. Verbal Comprehension involves retrieving information or knowledge that is well-known and well-practiced. Reasoning involves going beyond the information given by inference or inductive implication. These terms are used to represent theoretical distinctions made by many researchers, particularly Cattell and Horn (see Horn, 1978), and which are widely believed to be differentially related to aging. Perceptual Speed represents one class of intellectual functioning that is believed to be unusually sensitive to various aging processes and is intended to represent the speed with which information is processed in the nervous system. All classes of ability constructs in the system are "latent variables," analogous to factors correctly observed, they are variables.

Verbal Comprehension include vocabulary, comprehension tests. Reasoning include inductive reasoning, solving tasks, formal Speed indicators include time, perceptual speed of simple cognitive tasks. Performance is the principal differences.

The model in Figure 1, a regular pattern of causal in respected causal pattern is believed to influence both Per- reasoning. Many studies and evidence suggest that slowing of the speed with which information is processed. Secondary influence both Per- reasoning. Several studies Abrahams and Horn (1971; Abrahams and Horn, 1971) that health status, part status, may incur increased even when chronologically Close scrutiny of the data in Schaeie's (1979) Seattle indicates that it is in the age declines in inductive reasoning. It is also in the age and that the chronic disease. This population level of possibility of a health in The terminal decline in reasoning are viewed as being the inferences with various aspects of intellectual function.

Current, but as yet unexplored, has used archival data to explore. Although the model works well with aspects, it is apparent that primary aging to Reasoning may violate the Cascade pattern of health constructs have a disappointing amount of classes of intellectual abilities. Broader or more sophisticated health status will show...
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Cascade Model, which
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are “latent variables,”
alogous to factors; since they are not di-
rectly observed, they are indicated by multiple
variables.
Verbal Comprehension indicators would in-
clude vocabulary, comprehension, and infor-
mation tests. Reasoning indicators would in-
clude inductive reasoning, abstract problem
solving tasks, formal operations, etc. Percept-
tual Speed indicators include choice reaction
time, perceptual speed tasks, and other indices
of simple cognitive tasks for which speed of
performance is the primary source of individ-
ual differences.
The model in Figure 1 postulates a particu-
lar pattern of causal influences. The hypothe-
sized causal pattern is as follows. Primary ag-
ing is believed to influence Perceptual Speed
but not the other aspects of intellectual func-
tioning. Many studies in the research litera-
ture suggest that normal aging results in a
slowing of the speed with which information
is processed. Secondary aging is hypothesized
to influence both Perceptual Speed and Rea-
oning. Several studies (Wilkie and Eisdorfer,
1971; Abrahams and Birren, 1973) suggest
that health status, particularly cardiovascular
status, may incur increased losses with age,
even when chronological age is held constant.
Close scrutiny of the variable curves from
Schaefer’s (1979) Seattle project also suggests
that it is in the age decade of the fifties that
decline in inductive reasoning become notice-
able. It is also in the age decade of the fifties
that the chronic disease rate greatly increases.
This population level correlation suggests the
possibility of a health influence on Reasoning.
The terminal decline influences of tertiary ag-
ing are viewed as being pervasive, and there-
fore causal links are postulated with all three
aspects of intellectual functioning.
Current, but as yet unpublished, research
has used archival data to evaluate this model.
Although the model works well in many re-
spects, it is apparent that a causal link from
primary aging to Reasoning is needed, which
violates the Cascade pattern. Moreover, the
health constructs have accounted for only a
disappointing amount of variance in the two
classes of intellectual abilities. It may be that
broader or more sophisticated indicators of
health status will show a better result. It is
also possible that the indicators of primary
aging may already be sensitive to the health
construct and that this construct may there-
fore be empirically redundant. The important
point, however, is that this kind of deployment
of causal modeling allows for an analytical
consideration of different aspects of the aging
process.
Although this kind of model can be em-
ployed for a wide variety of topics in the study
of human aging, it is particularly germane to
research situations that are not ripe for exper-
imental manipulation or that are intrinsically
suited for meaningful or ethical manipula-
tions. Although the Cascade model presented
here is a decrement model, it would be possible
to apply the decrement approach to other
kinds of conceptualizations. For example, a
decrement with compensation model could be
tested if suitable constructs and related indica-
tors were developed for factors that compen-
sate for aging effects. Along the same lines,
it would be possible to investigate cohort dif-
fences if suitable constructs and operational-
izations were developed. Furthermore, various
topics of adjustment and morale could be ex-
plored in the context of this type of model
(e.g., Lawton, 1982). Thus, it appears that
there is wide potential for the application of
this approach in behavioral aging research.

Kinds of Psychological Research in Aging

Psychological research in aging can be divided
into four broad categories: pre-experimental,
experimental-manipulative, theoretically ori-
ented, and intervention oriented. Although
these categories are not always mutually ex-
clusive, enough studies fall into a given cate-
gory to justify this kind of a framework. Pre-
experimental research is descriptive work that
ideally sets the stage for the more logically
incisive studies exemplified by the second and
the third categories. Even in situations where
a controlled experiment has already been con-
ceptualized and meaningful manipulations al-
ready identified, it is often necessary or desir-
able to carry out preliminary parametric
estimation studies as a prelude to further ex-
perimentation. In other situations, the nature
of the phenomena being studied may limit the
extent to which meaningful, ethical manipulations are possible or technically feasible. Certainly, controlled experiments are preferable. They provide a certainty of interpretation and a hardiness of inference that is rarely, if ever, possible in descriptive studies of behavior. There is little doubt that the rate of progress of various areas of study within psychology is closely related to the degree to which the experimental method is deployed. Unfortunately, not all topics within the area of behavior lend themselves readily to this approach. The third category consists of theoretically oriented research. Usually, in new areas of research, descriptive and manipulative studies lead to a crisper understanding of the phenomena of interest, which fosters the development of theories or models that attempt to explain the behavior. The fourth category concerns interventions, with the emphasis on changing behavior in a desirable way. Although such interventions are sometimes undertaken outside of the research tradition of the three other categories, it is widely believed that they are likely to be more successful when based on a firm support of the empirical results and theoretical understanding gained from previous research.

There are many examples of pre-experimental studies in aging research. In addition to an over-abundance of cross-sectional studies, an increasing number of longitudinal studies are being reported. Botwinick and Siegler (1981) recently reported descriptive results of intellectual functioning from a Duke Longitudinal Study that emphasized the role of attrition in longitudinal studies. Another example of descriptive research from the same study is that of Siegler, George, and Okum (1979) regarding personality variables. Considerable stability of personality was found with age. A project that in some ways is the most extensive yet undertaken in human development is the sequential study of Schaie (1979) and his colleagues, who followed individuals across their adult life-span for over two decades, describing age relationships for subtests of the Primary Mental Abilities Test. Schaie concluded that cohort differences played an important role in cross-sectional age differences. A number of studies of the factor structure of intellectual abilities in old age have been carried out (Cunningham and Birren, 1980; Cunningham, 1980a; 1980b; 1981). In general, it was found that ability structures were very similar in the old who were compared. However, with the young, factors tended to be more highly intercorrelated, particularly for very rapid tasks.

There are many examples of experimental manipulations. One is a study by Berg, Hertzog, and Hunt (1982) of median reaction times in several adult age groups. They varied degrees of mental rotation and practice over several days. Although practice had the effect of slowing responses in all groups, age differences were not reduced, and it was concluded that age changes in the speed of cognitive processing play an important role in responses to spatial ability tests. Kaussler (1982) provides a very scholarly review of the experimental psychology of aging.

The goal of many of the studies in aging research is the achievement of theoretically oriented studies, regardless of the details of procedure. Most of the studies in the psychology of aging involve theories taken from the context of "mainline" psychology and applied to elderly individuals. In some cases, it is a matter of evaluating the extent of their generalizability. In other situations, theories developed in mainline psychology result in predictions directly applicable to older persons. One example of this is the paper by Hasher and Zacks (1979). These researchers developed a distinction between "automatic" and "effortful" processing, which involves differential attention demands in memory functioning. Implications from this conceptual distinction are drawn for various age groups, including the elderly. For example, empirical research suggests that processing frequency information is not influenced by aging or depression. Another example of theoretically oriented research concerns perception of persons and stereotypes. Brewer, Dull, and Lui (1981) investigated young people's stereotypic perception of different prototypes of elderly people in the framework of the Rosch theory of natural categories. The results suggested that stereotyping of individuals occurs in basic rather than superordinate categories.

Unfortunately, most of the oriented research involves a shortage of efforts to establish of behavior regarding aging. An example of such theories is the speed advanced by Birren. Ideas regarding cautious experience (1978), and the relevance in a life reviews (1975).

An increasing number of studies are oriented toward behavior or circumstances in which Willis, Blieszer, and Baltes (1981) found performance of the elderly to be superior to that of their peers, widely believed that could be improved through procedures. Although improvements remain in some domains (1981), the results them support for a balanced understanding between age and intervention. One of the important points demonstrated improvement of the practice does not contradict others that does clearly show that death is inevitable or immutable. Between what is natural and is an important one for any modifiability of behavior subsequently found to be natural. This perspective, nonetheless, is the theoretical understanding of aging. Other interventional studies (Schulz and Hanusa, 1977) concerns about the possible limitations of interventions.

Theory and Selection of Variables

Psychologists use three types of sources of variables to explain aging, those arising from (1) experience, (2) individual choice, and (3) biological organism. Few of the interventions can be manipulated experimentally, but these ethical reasons.
Unfortunately, most such theoretically oriented research involves theory "borrowed" from other areas of psychology in one of the senses described above. There is a distinct shortage of efforts to establish genuine theories of behavior regarding aging in the elderly. Examples of such theories are the ideas regarding speed advanced by Birren (1965; 1974), the ideas regarding cautiousness advanced by Botwinick (1978), and the need to integrate experience in a life review proposed by Butler (1975).

An increasing number of intervention studies are oriented toward improving the behavior or circumstances of the aged. For example, Willis, Blieszer, and Baltes (1981) showed that performance of the elderly on tests of figural relations, widely believed to be age sensitive, could be improved through training procedures. Although interpretations of these findings remain in some doubt (e.g., Donaldson, 1981), the results themselves are important for a balanced understanding of the relationship between age and intellectual functioning. One of the important points is that the demonstrated improvement of an ability with practice does not contradict decrement models but does clearly show that declines are neither inevitable nor immutable. The distinction between what is natural and what is inevitable is an important one for aging. Furthermore, any modifiability of behavior, even if it is subsequently found to be narrow from a transfer perspective, nonetheless serves to enrich the theoretical understanding of the phenomena of aging. Other intervention studies (e.g., Schulz and Hanusa, 1978) serve to reinforce concerns about the possible negative impact of interventions.

Theory and Selection of Experimental Variables

Psychologists use three general classes of variables to explain the phenomena of aging, those arising from (1) the structure of experience, (2) individual decision and choice, and (3) biological changes in the organism. Few of the important variables can be manipulated experimentally in human beings for ethical reasons. Particularly is there reticence to alter the suspected major types of emotional experience. In a similar way, we are restricted from studying decision processes in important life circumstances—e.g., life or death choice or financial loss—and have to hope our micro experimental studies of decision processes reflect those that human beings use in complex decisions under ecologically valid circumstances. For this reason, psychologists must (1) experiment with micro learning experiments using cognitive material, hoping that it will extrapolate, (2) use natural history methods and correlational analyses, or (3) use experimental studies of other species and again hope that the results extrapolate to human aging.

If we regard the structure of experience as the result of culture, the "DNA of society," then cross-cultural studies may provide comparisons that, although not experimentally conclusive, still offer information about how behavior is organized over time. These studies do not manipulate what we suspect as being causal in aging, but we can compare them to many "natural experiments," and such comparisons can lead to inferences.

One of the models that has influenced the selection of variables in naturalistic and experimental studies is that provided by the computer. One can speak of aging as being caused by alterations in "hardware" (biology) or in "software" (experience), and perhaps to their interactions. Certainly much of the behavior shown with advancing age is the result of the programming of our software as we grow up and grow old in a particular culture. Few scientists, moreover, would contest the idea that some behavioral changes with age are hardware induced.

If we were to replace time with other putative causal variables in the software, then time would remain as a causal variable in the hardware. Ideally one would like to say that if the hardware of the organism and the decision processes were held constant, the effects of experience that have a particular effect on behavior would define aging. Logically, of course, it is impossible to hold organisms constant. Thus, the experiment can replace time with other variables only in one domain of the organism. Stated differently, time is a
ubiquitous variable, and if we attempt to explain time changes as dependent on other variables, it will simultaneously appear as an independent variable for all those conditions that we cannot hold constant. Any experiment on aging involves time as a dependent and an independent variable simultaneously. The idea that experimental studies should regard time or age as a variable that should be fully eliminated, or that it is infinitely eliminable, may be an ideal principle but logically an unobtainable goal for the complex behavior of living systems (Birren, 1959).

Recent developments in neuroscience appear to offer new ways of conceiving of behavior that suggest new ways of experimenting. For example, the brain/computer model assumes point-to-point communication of information that the hardware does not modify. Contemporary neurochemistry, on the other hand, indicates that the brain has many modulator circuits in which the point-to-point communication is modified or may not be transmitted, depending upon the transient states within the modulator systems. Over 40 chemical substances that are purported to have neurotransmitter properties have been identified. Such substances modify the state of activity of cells in the brain other than the cells from which they originated. One contribution to modern neuroscience is that it describes much more of the complexity of the nervous system, a complexity we sensed must exist but for which we had no model. The importance of such findings is that they provide the means of manipulating subsystems chemically so that the behavioral effects may be observed.

For many of the neurotransmitters there are substances that will selectively enhance (agonists) or suppress (antagonists) action. For example, one of the systems that has been implicated in aging is dopamine, a neurotransmitter suspected to decline with age in the mammalian nervous system. To mimic the effects of aging experimentally or to test the hypothesis that the dopamine system declines with age, one can introduce into the organism a dopamine antagonist called haloperidol. Alternatively, if the hypothesis is that aging is the result of an increased activity of a neurotransmitter, then an agonist can be introduced into the organism to mimic these phenomena. Not only may primary informational systems and modulators be manipulated experimentally, but a greater comparability of animal and human research may result. In addition, balances in behavior may be studied by using graded amounts of antagonists or agonists to increase the activity of one transmitter and decrease that of another. One of the characteristics of many aged persons is that they can do everything they did earlier in life but not do it so well. Thus function may be reduced with age but not categorically absent as it might be as a result of disease. Advances in neuroscience may thus lead to the design of experimental studies in which direct manipulation of neurotransmitter systems will be able to simulate the complex interactive phenomena of aging, e.g., hardware-software hypotheses.

In addition to modeling aging as a normal process of diminished or enhanced function, manipulation of the activity of selected neurotransmitters may also be used to model age-associated states such as depression or mania. As yet, we cannot reproduce Alzheimer's disease experimentally or significantly modify its course, but we can now begin to anticipate the design of such experiments. Not only is neuroscience beginning to provide a rational psychopharmacology of old age, it is also opening the door to the study of software-hardware interactions on an experimental basis. Thus, animals may learn a complex behavior and then be subjected to selective neurotransmitter modification. Conversely, the neurotransmitters may be modified in advanced of the learning. Another experimental advantage provided by current neurochemical knowledge about the brain is that it permits manipulations of different behavioral subsystems, i.e., those that are cognitive, affective, or effective, as well as those that relate to somatic regulation.

KINDS OF RESEARCH

Experimental Gerontology

Since the psychology of aging is part of the broader scientific effort of gerontology, it seems desirable to link the concerns of psychologists in explaining patterns of change with age with those to explore the phenomena viewpoints of physiologists, and morphologists (see Verzar, 1961, true of combinations of physiological research issues.

Organ Systems

One of the properties of that the effects of experience accumulated over time that there are some in the body whose function is related to the passage of time. Special attention has been given to the system, the endocrine system, and the cardiovascular system which have a high probability longevity of the organism, that experimental animal, cardiovascular or cardiac age, the frequent occurrence of heart and brain circulatory states associated with an event of aging in human beings, a cardiovascular disease in older adults, phenomena of aging not the pacemaker of aging aging.

More attention has been paid to the immune system and the process of aging.

RESEARCH EVALUATION

Researchers, teachers, and students are being asked to give a critique of a research proposal or a proposed study. Some research proposal or paper is a discipline that has produced an outline that poses questions to consider in arriving at an advanced graduate seminar based on the application of knowledge to various substantive areas. An outline that follows has been used in two earlier versions (Birren, 1970, and Birren and Robinson, 1976). It covers most aspects of the initial question to the empirical results.
RESEARCH ON THE PSYCHOLOGY OF AGING

with age with those of other scientists who explore the phenomena of aging from the viewpoints of physiology, biochemistry, physics, and morphology as well as the social sciences (see Verzar, 1963, pp. 4–5). This is also true of combinations of biological and neurophysiological research oriented toward behavioral issues.

Organ Systems

One of the properties of aging appears to be that the effects of experience and damage are accumulated over time. This would suggest that there are some archive-like systems of the body whose functions are more intimately related to the passage of time than are others. Special attention has been given to the immune system, the endocrine system, the nervous system, and the cardiovascular system, all of which have a high probability of limiting the longevity of the organism itself. Given the fact that experimental animals need not show cerebrovascular or cardiovascular disease with age, the frequent occurrence of diseases of the heart and brain circulation may not be intrinsically related to an evolved biological pattern of aging in human beings. In this sense, vascular disease in older adults may be a secondary phenomena of aging not reflective of a primary pacemaker of aging at the biological level. More attention has recently been given to the immune system and the nervous system in the process of aging.

RESEARCH EVALUATION

Researchers, teachers, and students are often asked to give a critique of a research report or a proposed study. Since the content of a research proposal or published article can resist dissection, it has proven useful to employ an outline that poses questions for the reader to consider in arriving at an evaluation. Advanced graduate seminars are sometimes based on the application of such an outline to various substantive areas of interest. The outline that follows has been adapted from two earlier versions (Birren, 1959a, pp. 38–40, and Birren and Renner, 1977, pp. 31–34). It covers most aspects of research from the initial question to the conclusions drawn from the empirical results.

Naturally, the evaluator must use his judgment as to which aspects of the outline are most pertinent to a given report or proposal. The components of research studies and their published reports are, characteristically, not uniformly strong in quality. It is often useful to consider each aspect separately in arriving at an evaluation of a dissertation or research proposal or in determining whether a published article represents a significant addition to knowledge. Although intuitive thinking is part of the process that accompanies the weighing of the strengths and weaknesses of a study, the following evaluation outline is presented in the hope that a more logical and analytical approach will help to guide those of us who find it necessary to make judgments about the quality and meaning of research.

(A) Problem

1. What is the purpose of the research?
2. Is the problem clearly and concisely stated so that it can be investigated or solved?
3. Does the research problem have a conceptual framework?
4. Is it clear whether this is a descriptive or normative study, a survey, a study to test a hypothesis, or some combination thereof?
5. Is the context of the problem described in such a way that it is readily apparent what is included and excluded from consideration?
6. Are the essential concepts necessary to understand the problem defined?
7. Are the terms defined clearly? Is there confusion in the definition of terms? Do they have arbitrary or multiple meanings?
8. Are assumptions stated and are they tenable in the light of existing research literature?
9. Is the literature of previous studies adequately reviewed or taken into account?
10. Is there an attempt to make a contribution to systematizing previous information?
11. Are the hypotheses and objectives stated in the context of the research problem?
12. If a hypothesis is tested, is the theory...
from which it is derived sufficiently stated so that the relationship between the hypothesis and the theory can be evaluated?

13. Are the independent and dependent variables clearly identified and defined?

14. Are the consequences of possible findings pointed out?

15. Is the scope of the problem too large for the resources available and the methods which can be used? Is the proposed work only a pilot study, a kind of example of the phenomena of interest, or a small part of the whole problem? If so, is it identified as such?

(B) Experience of the Investigators

1. Are the investigators trained in the particular methods and procedures used?

2. Do the investigators have experience with the particular population studied?

3. If the study is large in scope and therefore demanding in terms of administrative responsibility, has the investigator the skills or experience to manage the project?

(C) Design

1. Was the design of the study planned and evaluated beforehand? Or does the study (as is often the case in longitudinal studies or archival expeditions) take advantage of existing data. If so, are the limitations of the available data explicitly discussed?

2. Is the design capable of providing an answer to the problem posed? Is the design applicable to, oversimplified, or unnecessarily complicated for the problem?

3. Does the design take into account all the pertinent aspects of the study: subjects and materials, environments, manipulated variables or stimuli, measurements and observations, and statistical methods?

4. Were alternative designs considered and the basis for their rejection given?

5. Are the compromises made with an ideal design described?

6. Is the design succinctly presented, as in a diagram, so that it can be readily understood?

7. Is the design an efficient one to solve the problem in terms of money, subjects, and time?

8. Are the statistical methods to be used determined before the experiment starts?

9. Was the level of significance with respect to accepting or rejecting the null hypothesis determined and discussed before the study was undertaken?

(D) Sampling of Subjects and Materials

1. Was the sample adequately described?

2. Of what population, if any, was the sample representative?

3. Was the population or subgroups of the population sampled?

4. Was the sample an appropriate one for the purposes of the study?

5. Was the sample collected for the purposes of this study or for some other purpose?

6. Was there any possibility of the introduction of a sampling bias?

7. Were the subjects selected according to the design of the study and with regard to the statistical methods to be used?

8. Was the sampling adequate to result in a standard error small enough for the purposes of the study?

9. If animals were used, have the conditions of the colony been evaluated and described?

10. Has the health of the subjects been evaluated and described?

11. Were the subjects taking medication? If so, could this have influenced the results?

12. Was there any loss of subjects or mortality in the sample, and, if so, is there a discussion of its possible effect on the results?

13. If replacement procedures for missing subjects were used, were such procedures adequate and were they sufficiently described?

14. Were the methods of sampling described as follows?

(a) Simple random

(b) Systematic

(c) Multistage

(d) Stratified

1. proportional

2. optimum

3. disproportionate

(e) Cluster

(f) Stratified or

(g) Biased

(h) Purposive

(i) Incidental

(j) Repetitive

(k) Judgment

(E) Controls

1. What controls were used in the sampling (e.g., matching)?

2. What controls were used in the setting or administration of the study?

3. If relevant, were controls used in the gathering or interpretation of data?

4. Were placebo effects controlled?

5. What controls were used in the manipulation of controlled variables?

6. Were the conditions under which the subjects or were acutely controlled?

7. If controls were not used, were any conditions analyzed with reference to conditions?

8. Were any important conditions usually found that, if so, was the

(F) Measurements and Procedures

1. Were the techniques of observation and

2. Was a pilot study made regularly if the material for the present experiment?

3. If standardized tests were used, reference to

4. Were all variables controlled and quantified?

5. Were the data collected objectively? What guard against post-hoc and tabulating?

6. If several measures...
(E) Controls
1. What controls were exercised through sampling (e.g., twins, littermates, and matching)?
2. What controls were exercised by selection of setting or natural habitat?
3. If relevant, were blind or double controls used in the gathering, evaluating, and interpretation of the data?
4. Were placebo effects controlled?
5. What controls were exercised by experimental manipulation? Were the controlled variables adequately described?
6. Were the conditions the same for all subjects or were adjustments made or a treatment given?
7. If controls were changed, were results analyzed with respect to the altered conditions?
8. Were any important controls absent that are usually found in a study of this type, and, if so, was the absence justified?

(F) Measurements and Data Collection
1. Were the techniques of measurement or observation adequately described?
2. Was a pilot study conducted, particularly if the materials were constructed for the present experiment?
3. If standardized tests were used, was there reference to normative data?
4. Were all variables of the study categorized and quantified sufficiently?
5. Were the data collected accurately and objectively? What checks were made to guard against possible error in collecting and tabulating data?
6. If several measures were taken, was a reasonable and predetermined time schedule followed?

(G) Data Treatment
1. Were the methods of recording and the treatment of data described?
2. Were the statistical procedures clearly described?
3. Were the statistical procedures used appropriate for the research problem and the data?
4. If several different statistical analyses were made, is it clear how they are related? What contribution did each analysis make to the results?
5. Were the underlying assumptions of the statistical tests violated because of the methods, sampling, or nature of the data?
6. Were the tests of significance described and are they suitable?

(H) Results
1. Were the results or data adequately presented so that the reader can verify the author's statements about them?
2. Were the results clearly reported in tables and graphs so that others may use the data or reproduce the results? Were means and variances reported?
3. Were the essential relationships posed by the problem analyzed and tested for significance? Were trends interpreted as if they were statistically significant?
4. Were the results a logical product of the procedures and analyses, and were they relevant to the problem as originally outlined? In other words, was there a logical connection between the problem, the hypotheses, the design, the results and the conclusions?
5. Were the statistical limitations of the study appreciated and explained?
6. Were estimates of error provided and sources of error identified and qualified?
7. If several related variables were examined, were the results consistent?
8. Were the results internally consistent?
9. Were the actual results confused by unlabeled speculation or conjecture by the researcher?
10. Can the results be attributed to a treatment, spontaneous recovery, or other effects?

(I) Conclusions
1. Does the author draw conclusions about the major problem posed in the study?
2. Are the conclusions clearly supported by the data? Are there inconsistencies between the results and conclusions?
3. Are conjectures and speculations clearly separated from the researched facts? Is there a clear, logical thread running from the problem statement through the discussion of the meaning of the findings?
4. Are the limitations of the study clearly stated?
5. Are the results generalized to the population at large? What rationale is provided, and is the generalization valid?
6. Have unexpected results been rejected merely because they do not agree with the researcher's expectations or because they appear to conflict with common sense?
7. Are statistically nonsignificant tests evaluated, or are they interpreted to be meaningless and unimportant?

nonsignificant trends in the results section promoted to significant findings in the discussion section?
8. Are important reservations or qualifications pointed out? Are possible artifacts or spurious relations pointed out?
9. Has the author overlooked important aspects of the results?
10. Can additional questions or new hypothesis be generated from the study, and are they stated?
11. Are the results interpreted in relation to other published information, and is their significance for related fields pointed out? What are the implications of the results for knowledge in the field?
12. Are the methods used reviewed critically in the light of the obtained results?
13. Are the interpretations, implications for future research, and the development of new methods appropriate for the scope of the present study, or do they reflect an overestimation of the significance of the study?
14. What is the potential importance of the study, and what scientific or practical advances will result?
15. Are necessary modifications of theory or current interpretations of data or practice pointed out?
16. What contributions have been made to the theory of the subject?

EPILOGUE
In the previous version of this chapter (Birren and Renner, 1977), investigators were urged to undertake experimental studies on aging. It was recognized, however, that although experimental research is usually accompanied by fewer errors of interpretation, it is also difficult for psychologists to do major experimental studies of human aging for ethical reasons. Psychologists thus tend to use micro learning experiments, for example, and hope that these transfer to more complex aspects of human behavior. The other more common approach is to use description and natural history methods, correlational and "natural experiments." The near future will allow experiential studies of an attempt to replace the variable involved in a rate, therefore, for potential to "encourage a description of the psychology of aging while vali mental control of the organism." (Birren, 1970, p. 135)

Aging is such a complex process that we must approach it with a broad view. Psychologists have identified four major scientific areas: aging mechanism, organism, environment, and society. (Pepper, 1942). Yet even a basic understanding seems to have some important implications. Our knowledge of the biology of life is less likely to be invalidated when dealing with issues of aging than when they are not. Generalizations about aging are transformed for the individual member of a species. What will be is not necessarily what was. What will the future bring with it? What will tell us "where" to look for intervention, and what will tell us "how" to look for intervention? It is not clear which of these trends that might help to map the psychology of aging.

Molecular biology is a powerful tool for identifying the aging process, as well as for their localization. They have the potential to be adapted to new organisms. The course of life of experimental organisms can be undertaken in efforts to control that specific aging is not the result of phenomena. Certainly it is clear that the genes responsible for the aging process, as in found Alzheimer's disease, are altered by the experimental manipulation. The depression of the genes responsible for aging may be necessary. The repertory of laboratory animals which psychologists could use to understand the aging process.

THEORY AND METHODS IN THE PSYCHOLOGY OF AGING
ods, correlational analyses, and occasionally “natural experiments.” It is not likely that the near future will allow us to do major experimental studies of aging in which we attempt to replace the suspected independent variable involved in aging. It seems appropriate, therefore, for psychologists to continue to “encourage a descriptive and analytical psychology of aging while striving toward experimental control of the major causes of aging” (Birren, 1970, p. 135).

Aging is such a complex subject that we must approach it with many different points of view. Psychologists have been said to have four major scientific paradigms: formism, mechanism, organism, and contextualism (Pepper, 1942). Yet each of these world views seem to have some inadequacy when we contemplate what is perhaps mankind’s greatest dilemma, his time-related mortality. Perhaps our bread-and-butter concepts of the organization of life are less likely to seem inadequate when dealing with issues of early-life development than when they are used to provide generalizations about aging, how the organism becomes transformed from a young to an old member of a species. One suspects that the future will bring with it new paradigms that will tell us “where” to look, how to “explain,” and new ways of conducting experiments. It seems appropriate at this point to point out some trends that may prove fertile for the psychology of aging.

Molecular biology is now providing methods for identifying the actions of specific genes as well as for their localization and their transfer to new organisms. Modification of the course of life of experimental animals can soon be undertaken in efforts to understand the control that specific genes exercise on the timing of phenomena. Certainly the identification of the genes responsible for brain deterioration, as found in Alzheimer’s Disease, presumably by the experimental manipulation of the expression of the genetic trait, would be a great step forward. Experimental gerontology based upon molecular biology may soon be in the repertory of laboratory methods, one from which psychologists could gain much in the understanding of aging in experimental animals.

Yet another major paradigmatic shift is underway in the neurosciences, which are providing ways of examining behavioral interactions by modifying particular neurotransmitter substances. Thus the nervous system, so important to complex behavior and the basis of human existence, may soon be a suitable laboratory in which to study aging. The study of the effects of behavior which may be organized on the basis of experience in relation to the effects of genetic determinants is a more perplexing prospect. Perhaps the perplexity arises because our paradigms of the nervous system do not now embrace sufficient aspects of the complexity of the organization. To this end, we introduced the thoughts of Yates since his interests lie in characterizing a science of complexity, a one-science approach than can embrace the range of phenomena from human social behavior to molecular events (Yates, 1982). Certainly psychologists are in need of new paradigms to help them ease out of the rigid molds of characterizing phenomena as either biological or social.

One example of a trend in social science research is that of Schinnar and Stewman (1978), who proposed a model of social mobility in which both age and duration in a social class were considered. In their model, “mem-ory duration patterns” are introduced, and the authors suggest a “concept of ‘social’ or ‘psychological’ duration, called duration memory, which records duration in terms of its effect on movement, rather than by simply being a chronological ‘counter’ ” (Schinnar and Stewman, 1978, p. 63). The model is relevant to aging since different age groups can behave differently even though they may have been in the same period of time in the same social space. Here are the beginnings of a social science modelling that embraces many of the complex features of aging and human social life that we have neglected in the past because of our limited paradigms and analytical methods.

One of the dramatic growths in social movements in recent years is the trend toward the formation of self-help groups. This has focused on groups of vulnerable individuals such as alcoholics, drug users, sex-offenders, rape victims, etc. Presumably the learning that one
obtains in such groups is different in some important ways from the learning individuals achieve alone, e.g., by reading. One thought is that self-help groups not only supply a large body of information in a cognitive sense but also deal with emotions and therefore provide subjective support in ways that individuals cannot secure alone. The following widely quoted comment by Mowrer is relevant: “You alone can do it, but you can’t do it alone” (Mowrer, 1964). While this is not yet made explicit, self-help groups appear to assume that the human subject is interacting in a group at several levels which cannot be simply understood in either biological or social terms as we now use them. As self-help groups are developed for selected older populations or for families with older members, the new experimental opportunities presented will enable us to understand better how behavior becomes organized and the circumstances under which it become disorganized. The original chapter of this book pointed out that there is much to be optimistic about in the growth of our understanding of the processes of aging but that there is very little systematic theory to help us organize the information already existing. “Research sectarianism is another impediment to research on aging that has perhaps blocked theoretical formulations that take into account the fundamental biological as well as social nature of mankind” (Birren and Renner, 1977, p. 35).

At this point, it is perhaps appropriate to reflect upon the different obligations we have as members of a species that is hopeful of survival as well as our obligations to survive as individuals. It would seem that natural selection has favored reproduction during young adulthood when there is the least risk in terms of the possibility of defective offspring. Conceiving at an age when we are neither too young nor too old would seem to provide the circumstances under which an optimum germ cell would develop. If aging provides an advantage to the species by decreasing the probability of conception by old parents and thereby of defective offspring, it leaves to the individual an uncertain struggle for biological and psychological survival. Under optimal conditions of a changing body and changing environment, the older person would seem to seek to maintain maximum adaptive capacity and to establish an equilibrium or homeostasis with the biological, psychological, and social forces acting upon him. This implies that the executive portion of the nervous system that is involved with voluntary activity is directing behavior toward achievement of a balance that is congruent with a lifetime of experience—a unique set of values and personality. The effort to establish a personal equilibrium among the forces that affect us results in some of us becoming wise as we grow old, more valuable to ourselves, to others, and to the broader flow of events that comprise a history of human destiny.

REFERENCES


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REFERENCES

Birren, J. E. 1973. Reaction time and behavioral predisposition to
Age. J. Gerontology 28, No. 4: 199-203.

Birren, J. E. 1980. The changing family and health. In Handbook of
Aging, eds. J. E. Birren and K. W. New York: Van Nostrand

Psychology of Aging. New York: Van Nostrand


Brewer, M. B.; Dull, V.; and Lui, L. 1981. Perceptions of


Cowdry, E. V. 1952. Aging of individual cells. In Cowdry’s Problems of A


INTRODUCTION: GENERAL RESEARCH DESIGN

Research designs are arrays of gathering empirical infor-

mables and their interrelations to facilitate their interpretation. As with any cumulative decades of practice, concep-
tualization and broadening led to a more or less formal and criteria that can be used in the pursuit of emp-
irical research questions (Cattell, 1963; Cattell, 1966a; Cattell, 1979; Edwards, 1950; Uniformal principles, though broad, and when one gets of actually integrating en-
phatic questions, the two becomes salient. Search in aging, Schaie fundamental inseparabilities of the nature of personal and research design con-
straints and limitations, imposed by the problem.