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5

FUNCTIONAL AGE

Examination of a Concept

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It has long been argued that people differ in the rate at which they manifest characteristics of aging, and many researchers have attempted to find a better index than years since birth to reflect an individual's susceptibility to processes of aging. The term ***functional age*** has been used as a descriptive label for many of these research efforts, in that it has been suggested that functional capabilities are likely to be more meaningful than mere chronological age for characterizing the status of an individual. Although the goal of monitoring a person's capacity for functioning is certainly commendable, the concept of functional age has generated such controversy and confusion that the time may now be ripe to review the various foundations of this concept and the logic behind each of its multiple usages.

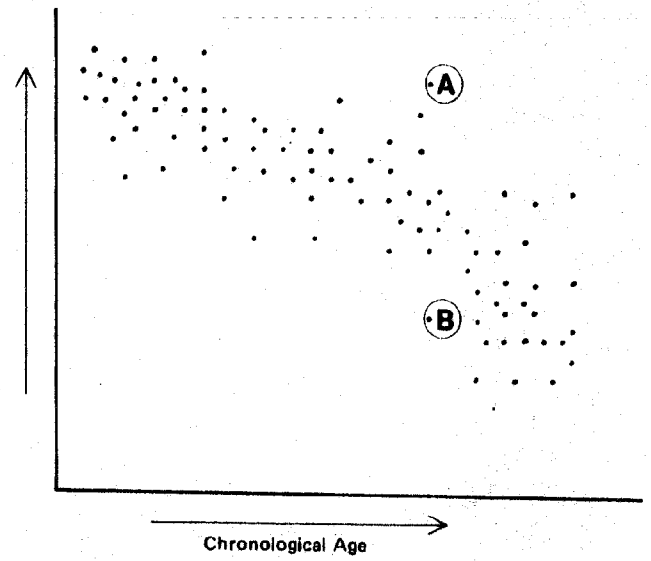
Before attempting to examine the functional age concept, it is useful to consider how earlier authors have defined functional age, and its related concepts of working capacity, effective age, psychological age, biological age, and physiological age. Some researchers have adopted a very broad interpretation, as reflected in the statement by Birren and Renner (1977) that "functional age is an individual's level of capacities relative to others of his age for functioning in society" (p. 5). Others, however, have felt that functional age is more limited, as indicated by McFarland's (1973, 2) claim that functional age is the "... ability to perform efficiently the tasks involved in specific jobs." What appears to be a still different interpretation of the functional age concept has been proposed by several biologically oriented researchers who have suggested that functional or biological age should "... designate the position of the individual along his life span" (Birren, 1959, 18), or the

person's "... nearness to death" (Nuttall, 1972, 149). Perhaps the only common theme across these various efforts is the belief that the tremendous variability among individuals of the same chronological age makes it imperative that some alternative index be developed that is more sensitive to individual differences.

The point about the variation among individuals of the same age can be illustrated with the aid of a fictitious, but generally realistic, example presented in Figure 5–1. The ordinate of this diagram is unlabeled to allow applicability to several dependent variables, but in all cases a higher score represents better performance on the relevant dimension. Notice that while there is a tendency for the average scores to decline with increased age, there is considerable variability at each age. In particular, individuals can be identified who have scores above the mean value for the age group (A), and who have scores below the age group mean (B). Categorizing these people together simply because they share the same chronological age is clearly an extremely crude, and often misleading, basis for classification. As a first step toward improving classification, functional age researchers have sometimes proposed that an individual should be categorized according to the age at which the average score is equivalent to the individual's score. In terms of Figure 5–1, the person represented as A would be designated functionally younger than his or her age, while the person represented as B would be considered functionally older than the chronological age would indicate.

Although the logic of Figure 5–1 appears straightforward, the ordinate has

FIGURE 5-1 **Illustration of logic behind the functional age concept. The ordinate represents increasingly better performance on some variable, while the abscissa portrays chronological age. The individual labeled (A) would be considered functionally young, while the individual labeled (B) would be considered functionally old.**



deliberately been left unlabeled, and much of the confusion concerning the functional age concept may be due to the acceptance of different criteria or dependent variables against which the functional age measures are to be assessed and validated. Birren (1969) has suggested that possible criteria include survival of the organism, capability of independent living, presence of disease, work output, training capacity, accident-proneness, and even self-concept of age. If various research efforts focus on different criteria, then it is not surprising that the field of functional age research is in disarray. The rationale for the research, the specific measures examined, and the prognosis for the ultimate value of the concept will all vary, given the existence of such diverse criteria that could be used for evaluating the validity of functional age.

Another likely factor contributing to confusion associated with the notion of functional age is the many different meanings of the terms *function* or *functional*. In fact, it appears that most of the major functional age research can be placed into three categories according to the particular connotation of *function* implicitly guiding the research efforts. One synonym for *functional* is *effective*, in the sense that something that is functional is effective in accomplishing its goals. Research designed to assess an individual's competency in a particular occupation appears to be based on this conceptualization of *functional*, and will be called *occupational functional age*. The assessment of effectiveness need not be restricted to paid employment, however, and could be applied in the measurement of proficiency at any specific activity.

A second connotation of *function* is *purpose* or *utility toward a higher action*. It is in this context that biomedical researchers refer to the functioning of bodily systems and organs in contributing to the continued survival of the organism. This type of functional age will therefore be referred to as *biomedical functional age*.

Still another definition of *function* is the mathematical one in which function indicates a specific relationship among two or more variables. Researchers attempting to determine the interrelationship of behavioral and biological characteristics across the adult life span can be considered to be investigating this type of *structural organization of human functioning*.

The present classification system is by no means exhaustive nor mutually exclusive, and clearly omits several of the possible criteria mentioned by Birren (1969). Nevertheless, the occupational, biomedical, and structural categories appear to encompass the major usages of the functional age concept in the research literature, and therefore they can serve to organize and classify the discussion of functional age. Table 1 outlines the major characteristics of each functional age category and highlights the important differences among the various usages of functional age. A major theme of the current chapter is that while the different versions of functional age are superficially similar, they actually have very little in common, and to interchange their meaning and purpose only exacerbates the chaotic status of the functional age concept.

OCCUPATIONAL FUNCTIONAL AGE

The term *functional age* was apparently first introduced into the scientific literature by McFarland (1943) as a proposed substitute for chronological age in characterizing the proficiency of older workers. McFarland argued that it was unreasonable to judge a worker's ability to perform a specific job simply on the basis of his/her chronological age, as is the case when arbitrary ages are used to dictate job placement, training, reassignment, and retirement. A better basis for making occupational decisions was said to be information about the individual's actual capability for functioning in his or her job. This perspective has gained wide acceptance and has since been represented in legal decisions ("I believe strongly that functional capacity and not chronological age ought to be the most important factor as to whether or not an individual can do a job safely," Judge Parsons in Greyhound Bus Discrimination Case, cited in McFarland, 1973) and in popular slogans ("Don't judge a man's worth by his date of birth").

TABLE 1

Category	Purpose	Variable Selection Procedure	Validation Criterion	Role of Age
Occupational	Predict competence in specific class of activity	Behavioral representativeness in relevant class of activity	Job performance	Largely irrelevant
Biomedical	Assess relative health status	Importance for life maintenance	Survival	Surrogate for nearness to death
Structural	Determine interrelationship of human characteristics	Age sensitivity, theoretical predilection	Theoretical understanding	Continuum along which structural change is monitored

It is unfortunate that the word *age* has been used in this occupational context, because the basic idea was simply to replace arbitrary chronological age cutoffs with actual assessments of job performance in making personnel decisions. Less confusion and controversy would probably have resulted had terms like *functional capacity*, *functional competence*, or *functional ability* been used rather than *functional age*. Interchangeability of *age* with terms like *ability*, *competence*, or *capacity* could only be justified if a well-established, and widely recognized, relationship existed between age and competence. However, at the present time very few well-documented age-competence relationships are available in the scientific literature, and folklore stereotypes are too unreliable to provide a rational basis for personnel decisions.

As indicated by the earlier quote from McFarland (1973), the initial occupational version of functional age was closely tied to the work activities of the individual, and was primarily concerned with the assessment of job proficiency or competence. The job-specific nature of McFarland's proposal was evidently too limiting for many later researchers, and much of the subsequent emphasis has been upon the development of a battery of abstract measures that could have relevance for a variety of different occupations. This shift from the measurement of actual job competence to the attempt to assess general suitability for work has led to

many problems, however, and there is considerable doubt that any general assessment instrument will have much utility in actual employment situations. Among the most important objections to this *universal occupational competence* ideal are that job requirements differ so greatly from one job to another that no single set of measures would be relevant for more than a very small number of occupations, and that years or decades of experience performing a job may have led to the acquisition of different modes of performance that are not reflected in abstract job-independent measures.

Although some gerontological researchers seem to believe that a single index of functional age might be possible and desirable (e.g., Shock, 1981), nearly all vocational guidance counselors recognize that the great diversity of possible jobs requires that many different skills and aptitudes be assessed to determine suitability for various occupations. Actually, the necessity of obtaining measurements on a variety of factors rather than attempting to derive a unitary index was pointed out by Heron and Chown (1967), who advocated the development of functional age profiles. Birren (1969), Costa and McCrae (1980), and Salthouse (1982) have also made similar arguments against the feasibility of a unitary index. Moreover, simply expanding the number of different functional ages to be considered also fails to solve the basic problems, as revealed by the following discussion.

One example of a relatively sophisticated personnel selection instrument is the General Aptitude Test Battery (GATB) and its companion set of Occupational Aptitude Patterns (OAPs). The GATB consists of 12 subtests which are combined to provide scores on the following nine aptitudes: Intelligence, Verbal Aptitude, Numerical Aptitude, Spatial Aptitude, Form Perception, Clerical Perception, Motor Coordination, Finger Dexterity, and Manual Dexterity. An individual's profile across the different aptitudes is then compared with configurations of aptitude scores considered optimal for various families of occupations. Thirty-six major Occupational Aptitude Patterns have been identified, although the requirements of nearly any specific job could be individually defined in terms of a particular configuration of the nine aptitude scores.

Several large-scale studies have been conducted analyzing the effects of age on GATB performance (e.g., Droege, Crambert, and Henkin, 1963; Fozard and Nuttall, 1971; Hirt, 1959; Stein, 1962), and all have reported that increased age is associated with lower average performances on most of the aptitude scales. The declines are not large with several aptitudes (e.g., Verbal Aptitude), but statistically significant differences between 20 and 60 years of age have been found with each aptitude in at least one major study. These results have, in turn, led to dramatic age-related reductions in the number of occupations for which the individual is qualified according to the match of aptitude profiles with Occupational Aptitude Patterns. In fact, some estimates indicate that the average 60-year-old would be suitable for less than half of the 36 occupational families.

Because older workers are prevalent, and usually performing satisfactorily, in nearly all occupations in society, one should be somewhat skeptical about the application of aptitude measures such as these to the assessment of experienced older workers. While aptitude tests are frequently useful for purposes of selection, they may be meaningless when evaluating the proficiency of individuals performing a job they have held for some time. Over years or decades of experience a worker might be expected to develop efficient modes of performance that could not be easily predicted from abstract aptitude tests. The continued performance of specific activities could lead to the preservation of abilities that would otherwise deteriorate, or might allow for the compensation of abilities that are declining with age (e.g., Dirken, 1972; McFarland, 1943; Murrell and Griew, 1965; Welford, 1965). In either case, the results of selection procedures will frequently not be useful for assessing the performance of workers continuing on an old and familiar job.

Personnel decisions concerned with retention also differ fundamentally from those dealing with selection because the opportunity to observe actual job performance eliminates problems of low validity of predictor variables, and also allows consideration of such difficult-to-test characteristics as motivation, perseverance, responsiblity, and compatibility with colleagues. Furthermore, objective and accurate performance appraisal is necessary for meaningful and legally defensible (e.g., Walker and Lupton, 1978) personnel decisions, and the age of the individual being evaluated should therefore be as irrelevant as his or her sex, race, or ethnic background. There may be some resistance to the implementation of such prescribed performance appraisal systems, but a procedure of this type now seems to be dictated both by legal precedents and concern for the rights of the individual worker.

A second problem associated with the use of occupational functional age to predict work competence is that the introduction of age into the prediction situation appears to be an unnecessary, and largely irrelevant, complication. If the goal is to predict how successfully an individual will perform in a specific job context, the standard procedure is to evaluate the level of performance on a set of predictor variables of known validity. A variety of different decision rules can be used to relate predictor performance to personnel policies (e.g., hire the applicant with the highest score among current applicants, hire anyone above the minimum score, etc.), but in all cases it is the individual's performance on the predictor variables rather than his or her age that should be the most important determinant of the applicant's ability to handle the requirements of the job. To do as some functional age advocates seem to imply and convert scores on the predictor variables to a functional age index merely adds an extraneous complication because the functional age scale is not directly related to job performance.

Consider what would happen if an individual's scores on the GATB were to be used to develop a functional age profile. Norms are available describing the age relationships for each aptitude scale, and thus it would be a simple matter to express the person's score on each aptitude in terms of the age at which that score was the mean value. In other words, a set of nine "ages" could be derived to represent the person's functional level in each of the nine aptitudes. But where does this leave us? The functional ages are themselves useless for the purpose of prediction because all the validation with job performance was carried out with the original aptitude scores. In order to retain the correspondence with likelihood of occupational success, the functional age scores must be reconverted back to the original aptitude values from which they were derived. Translation to functional age in this case is, therefore, an unnecessary complication, confusing rather than clarifying the relationship between an individual's actual job performance and his or her scores on a set of predictor variables.

It may be argued that it is important to retain some temporal dimension in the assessment of occupational proficiency in order to represent dynamic changes

in competence. While it is often desirable to be able to measure rates of change in proficiency, it is questionable whether chronological age rather than job tenure or career age is the more meaningful index. In many occupations the contribution of on-the-job experience is so great that chronological age adds very little predictive power, and in most others there is likely an interaction between amount of relevant experience and chronological age. Without considerably more information, therefore, it is rather naive to think that progressive changes in proficiency on a job are related in a simple fashion to chronological age.

In view of the preceding discussion, the prognosis for the occupational concept of functional age is decidedly poor. Even if abstract measures could be devised that had general applicability and were as valid for experienced workers as for beginning workers, there seems to be no gain by referring to functional age rather than merely functional competence. Occupational functional age, therefore, appears to have little relevance to the three "ires" of personnel managers—whom to hire, should one fire, and when to retire. The first concern is best addressed by aptitude tests with known validity, and the latter two decisions should always be based on thorough and accurate performance appraisals.

It is true that knowledge of the average age of a pool of applicants may be helpful in predicting the proportion of applicants achieving a criterion score on the relevant predictor variables, but this information is no more useful at the individual level than comparable information about the racial or ethnic composition of the applicants. A fixed age for retirement has been convenient for purposes of social policy, and the high costs of health-care plans and pensions in combination with low potential return on the investment in training programs often bias decisions against older workers, but these considerations should not be confused with issues of competency. Furthermore, the failure to place an older individual into a suitable occupation because of low aptitude scores does not mean that he or she is to be abandoned, any more than would be the case for other "disadvantaged" members of the population. Vocational counseling and training, skill-development programs, and even job redesign are some of the alternatives that are often pursued after initial attempts at job placement are unsuccessful.

It is sometimes argued (e.g., Arvey and Mussio, 1973) that knowledge of a job applicant's age could be important if selection variables are found to have differential validity for different age groups. While this possibility cannot be unequivocally dismissed, there is little evidence of differential validity across age groups at the current time, and some research has actually indicated that validity coefficients are virtually unchanged after adjusting for applicant age (e.g., Droege, Crambert and Henkin, 1963). Moreover, even if such differential validity evidence were available, one must be careful in the evaluation of validity coefficients obtained from subsets of the population because restriction of the range of a variable (as would be done by focusing only on low-performing individuals, for example) almost always attenuates the value of a correlation involving that variable. In other words, if there is an age relationship with the predictor variables, it is likely that the validity coefficients obtained from a single age group will be lower than that of the entire population because of a restricted range of variation. This would lead to a spuriously small validity coefficient based on the data from a subsample of the larger population, even if the true validity remained the same.

There is one exception to the irrelevancy of age in occupational competency decisions, namely in occupations in which a sudden incapacitation can endanger lives. For example, airline pilots, air traffic controllers, bus drivers, and others in commercial transportation and related fields must continuously maintain a high level of performance in order to ensure passenger safety. In these types of occupations an unexpected stroke or heart attack could prove disastrous, and thus all possible precautions are taken to minimize the likelihood of such an occurrence. Unfortunately, current medical procedures are still too imprecise to make accurate predictions about the immediate likelihood of a stroke or heart attack in a given individual, and consequently there has been a reliance upon chronological age for determining occupational suitability because of the probabilistic relationship between age and cerebrovascular accident or cardiovascular disease. Health-related considerations are best viewed in the context of biomedical variables, however, and it is to this topic that we now turn.

BIOMEDICAL FUNCTIONAL AGE

A different tradition for functional age research has concentrated on the goal of attempting to measure rate of biological aging. Here the focus has been upon determining the relative rates of aging of different organ systems within the individual. Phrases such as "He has the lungs of a 20-year-old" or "His arteries are those of an 80-year-old" reflect the emphasis upon establishing separate age scales for the functional capacity of different organs. The presumption is that some weighted aggregate of the scaled age of each organ system would reflect the composite functional age of the individual. This biomedical conception of functional age, therefore, seems to be based upon the idea that because the deterioration of body parts is correlated with increased age, the amount of deterioration can be scaled in years of age. A major purpose of biomedical functional age is to predict a person's time until death, or in the words of Benjamin (1947), to develop for "... the individual what our actuaries and biostatisticians have figured out so ingeniously for groups" (p. 226).

Actually, there appear to be at least three distinct criteria to which this type of functional age might be applied, all relating to the individual's biomedical status. One criterion, certainly the least ambiguous, is the person's remaining life span or residual longevity. Here the various measures are combined in order to predict the number of years until the individual can expect to die from natural (i.e., other than accident, homicide, or suicide) causes. A second criterion is the current health status or vitality level relative to some population-defined optimum. Although it is not clear how such an optimum level of physiological functioning could be defined, deviations from that optimum level might provide a meaningful index of aging in the living organism. The third criterion is the rate of biological change of the organism, measured against some previous level of performance. Because there is only a finite amount of decremental change that any organism can tolerate, this criterion is related to both the remaining life span and the relative health status criteria.

The recognized difficulties in establishing an appropriate criterion (e.g., Birren, 1969; Costa and McCrae, 1980; Damon, 1972; Dempster, 1972; Dirken, 1972; Jalavisto, 1965; Jalavisto and Makkonen, 1963; Shock, 1981; Tobin, 1981) have hampered investigation of biomedical functional age in the past. Indeed, one of the earliest suggestions for the derivation of a biomedical functional age did not even specify a criterion against which the index was to be validated, and instead

proposed relying on clinical impressions of arbitrarily selected factors to obtain the global index (Benjamin, 1947). Perhaps not surprisingly, this initial proposal did not generate any serious research related to the concept of functional age.

The most popular approach for investigating biomedical functional age has been to use a multiple-regression equation to predict chronological age on the basis of measurement of a number of biomedical variables. A multidimensional perspective toward biomedical health status is generally assumed, although the number of predicted ages can vary from one for each variable to a single aggregate measure derived from all variables. Of course, the purpose of these analyses was not really to predict the individual's age, because it would obviously have been much simpler to ask the person directly about his or her age. Instead, chronological age appears to have been used as a surrogate for the true variable of interest—nearness to death. In other words, because older age is associated with a general increase in vulnerability of the organism to a wide assortment of diseases, years from birth is used as a convenient substitute for years until death. The predicted age derived from the regression equation then serves as the individual's functional age, with people having a predicted age greater than their chronological age considered functionally old, and people having a predicted age less than their chronological age considered functionally young.

Although plausible as an initial step in the investigation of biomedical functional age, Costa and McCrae (1980) have pointed out several major problems with this approach. One problem concerns the assumption that "... the difference between chronological age and functional age may be attributed to a difference in the rate of aging" (Webster and Logie, 1976, 549). The difficulty here is that it is extremely unlikely that all of the variation around the mean of an age group is attributable to different rates of aging. This is clearly an unreasonable assumption at young ages, and its likelihood is only slightly greater at older ages because of the confounding of aging rates with all other sources of individual differences (e.g., genetic background, nutrition and exercise habits, exposure to toxic environmental conditions, etc.). A much more reasonable, although still not infallible, assessment of functional aging rate might be possible by focusing on the amount of change in performance across two or more time periods. In this manner the absolute level of performance is factored out, and only the difference across various times of measurement is important. There is still no assurance that the change observed over past time periods will be similar to that in future time periods, but a longitudinal approach of this type seems the best available at the current time.

Costa and McCrae (1980) also mentioned the logical paradox confronting the multiple regression approach to the measurement of functional age in which the multiple regression equation can be too good to be useful. This occurs because the goal of the regression procedure is to maximize the correlation with the criterion variable, in this case chronological age; but if the correlation were perfect, predicted age would be the same as chronological age and there would be nothing gained from the regression procedure. The problem of ensuring that the variables are related to aging but not simply a more complicated index of chronological age was considered by Dirken (1972) and Jalavisto and Makkonen (1963), but has not yet been satisfactorily resolved.

Another problem discussed by Costa and McCrae (1980) was that there still has not been any convincing evidence that the measures investigated thus far are actually valid indicators of functional age by any of the criteria mentioned earlier. Some relevant research has been conducted, but the results are not yet conclusive. One attempt, reported by Costa and McCrae (1980) themselves, examined the hypothesis that "the functionally older would age more rapidly, and thus show greater changes ... over 5-and 10-year periods" (p. 33). Little support was found for this hypothesis since chronological age proved to be equivalent or superior to the functional age measures for predicting change. However, it is not clear why one should expect those who are functionally old to necessarily exhibit more functional change over a given period than those who are functionally young, and thus this particular test of validity can be questioned on theoretical grounds.

An intuitively more reasonable approach has been pursued by Furukawa, Inoue, Kajiya, Inada, Takasugi, Fukui, Takeda, and Abe (1975) and Webster and Logie (1976), who reported that their less healthy subjects (defined either by elevated blood pressure or subjective evaluation) had higher predicted (functional) ages than their healthy counterparts. These findings are therefore consistent with the suggestion that the healthy groups had slower rates of aging. However, true validation (at least for time until death as the criterion) will require repeated measurements until all subjects have died, and then carrying out retrospective analyses of the relationship between assorted variables and the time until death. Some relevant research has been reported (e.g., Birren, 1965; Borken and Norris, 1980; Jarvik and Falek, 1963; Tobin, 1981), but all either had very small samples or only a few measures available for comparison. Large-scale longitudinal studies of this type will be necessary to establish the predictive validity of biomedical functional age measures, with remaining life span or rate of change as the criterion. The use of relative health status as the criterion may not require longitudinal designs, but large-scale studies will still be necessary to provide the norms against which the individual's functional status can be compared.

Although there are definite problems with the notion of biomedical functional age, none seem irresolvable and the construct has enough potential value to warrant further investigation. One benefit of a valid measure of rate of aging is to provide a more efficient method than longevity analyses to assess the impact of environmental factors such as work conditions, chemical pollutants, nutritional habits, etc. As it currently stands, most adverse influences are detected only by noting an abnormally high death rate, and it would certainly be more humane if these factors could be identified before the death of the relevant population. An initial step in this type of research might be to compare populations known to differ in their age-specific mortality rates, under the assumption that the population with the higher death rate has an accelerated set of aging processes (e.g., Jalavisto and Makkonnen, 1963; Walthana-Kasetr and Spiers, 1973). The factors responsible for the above-normal death rates may not be reflected in the biomedical functional age measures, but such an approach appears to be more efficient than waiting until large numbers of a thoroughly measured population have died.

A second advantage of valid measures of the rate of aging concerns the possibility for intervention if detrimental factors can be detected before their influence has resulted in the death of the organism. If it is determined that a group of individuals is aging at an accelerated rate, special action might be taken to remedy the relevant conditions before it is too late for action. The possibility of intervention to alter the rate of aging leads to the intriguing implication that steps taken to increase life expectancy might add years to one's life and actually make the patient "grow younger" in a biomedical sense.

Still a third advantage of a biomedical functional age is potentially greater clarification of age relationships in that groups of individuals might be identified who are equivalent in a physiologically meaningful fashion. This could have relevance in certain occupations, although as discussed in the preceding section, actual job competency should be the most important determinant of most occupational decisions. Another useful application of biomedically equivalent cohorts would be in gerontological research. Much of the variability found across individuals within the same chronological age range might be reduced, and maturational trends more clearly revealed, if the subjects were known to be comparable in important biomedical dimensions.

In contrast to the situation with the occupational usage of functional age, the prognosis for a biomedical functional age can be fairly optimistic. Only very primitive research efforts have yet been pursued, and thus the empirical support for this conceptualization is still quite weak. There are also important problems that must be resolved before further progress can be made, including that of determining the specific criterion to be employed—remaining life span, relative health status, or rate of change in health. Nevertheless, the potential benefits of an accurate index of biomedical functional age are large enough that it is likely this issue will continue to receive the active attention of many researchers.

STRUCTURAL ORGANIZATION OF HUMAN FUNCTIONING

The third major category of use for functional age measures has been to determine the interrelationship of biological and behavioral characteristics across the adult life span. This emphasis has evolved in part as a by-product of the data obtained from the previous two categories of research. The availability of measures from an assortment of variables on individuals of different age ranges has allowed the examination of patterns of correlations (i.e., structural organizations) and possible changes in the correlational pattern or organizational structure across ages. The fundamental question from this perspective is whether the various characteristics that are age-related are themselves interrelated.

Research directed at discovering functional relationships between chronological age and a variety of biological and behavioral variables is important if for no other reason than to help establish the true nature of aging. Without an *a priori* definition of the concomitants of aging, investigators are forced to define it empirically by identifying the variables that exhibit a correlation with chronological age. That is, the essence of aging might be considered to be that assortment of anthropometric, biological, behavioral, and perhaps even social variables that exhibit consistent correlations with chronological age across different historical periods and different physical and cultural environments. Moreover, only if a phenomenon is clearly described by determining the interrelationships of major variables can one begin to explain it adequately. The goal of identifying the variables that are a function of age is therefore important as an initial step in the investigation of any process of aging.

Theoretical issues are also addressed by means of this correlational approach. For example, the distinction between one or many processes of aging might be investigated by examining the correlation of change scores across different variables. A single aging factor would be revealed if the assorted variables were highly correlated with one another, while alternative correlational patterns would indicate the existence of more than one process of aging. The evidence on this issue is currently ambiguous, as some researchers have discovered only a single aging factor (e.g., Clark, 1960; Jalavisto, 1965) while others have reported several factors with large age weightings (e.g., Birren and Spieth, 1962; Heron and Chown, 1967). The various studies have employed many different dependent measures, however, and it is not yet clear whether they should truly be considered contradictory.

Another important issue that could be addressed by means of this correlational approach concerns the nature of what is assumed to be the primary aging factor. One of the few general processes that has been proposed as a possible fundamental behavioral aging mechanism is the slowing of nearly all behavioral activities with increased age (Birren, 1965, 1974; Salthouse, 1982, 1985), and Jalavisto has summarized the reasoning behind a correlational approach for the investigation of this hypothesis:

> The assumption that there is a common process affecting speed of behavior implies that all tests which require speed should be intercorrelated. However, because they are all age-dependent, crude correlation coefficients are not informative. One could, naturally, calculate the partial correlation coefficients with elimination of the age dimension, but the factorial approach is probably more efficient. In factor analysis, intercorrelation if genuine, would manifest itself in a speed factor (Jalavisto, 1965, 355).

Indeed, the evidence from four relatively large (i.e., samples greater than 100) factor analytic studies indicates that speeded variables are consistently included within the aging factor, apparently regardless of the composition of the other variables in the analysis (e.g., Clark, 1960; Dirken, 1972; Heron and Chown, 1967; Jalavisto, 1965). Chown (1961) reported an additional factor analytic study which revealed that:

> The speed tests formed their own unique factor in the young group, maintained this to a lesser extent in the middle group, and were loaded most highly on the nonverbal intelligence factor in the old group. Thus among old people, but not among the young, these speed tests became a measure of intellectual capability and of the extent of the preservation of this function (Chown, 1961, 361).

Birren, Riegel, and Morrison (1962) reached a very similar conclusion in a later study of this type. A next step in the examination of this hypothesis might be to systematically vary the nature of additional biomedical or psychological variables and to determine the composition of the speed factor at different ages.

The advantage of this type of correlational approach to the investigation of theoretical issues is that unlike univariate approaches, data could be obtained that are relevant to both causes and consequences of what is suspected to be a fundamental aging mechanism. Causal factors could be inferred by examining the cluster of physiological variables found to be closely linked with indices of the suspected fundamental mechanism. Higher-order processes that are influenced by the primary mechanism might be identified by determining the behavioral variables that are related to the fundamental mechanism. Evidence such as this could not be considered conclusive, but it is a rich source of hypotheses about the nature of age differences.

An optimum procedure for determining the structural interrelationships of

variables might consist of the following four steps: (1) assemble as many relevant measures as possible (where relevance is determined by theory and domain of interest); (2) determine the values of these measures for many individuals of a given age; (3) identify the interrelationships or structural connections among variables; and (4) repeat steps (2) and (3) at different ages. Chronological age will then emerge as a dimension or continuum for examining possible changes in structural relationships among variables. The interpretation of the relationships will likely be dictated by theory—either one specified in advance of the data, or one inferred from the pattern of results obtained. Evaluation of the adequacy of the theory is based on the resulting degree of understanding of the mechanisms responsible for dynamic changes in relationships among variables.

It is important to point out that while the structural conceptualization of functional age has some aspects in common with the occupational and biomedical functional ages, the interrelationship of age-related characteristics need not be related to job performance or to residual life span. As an example, a discovery that visual and auditory changes are correlated across the adult life span would be interesting from the structural perspective, but would probably be irrelevant for the prediction of either job performance or future life expectancy.

While there has been little research directly aimed at discovering the structural relationships among biological and behavioral variables across the adult age range, it is likely that this topic will emerge as a distinct and separate area of research in the future. The complexity of the human organism seems to dictate a multidimensional and multidisciplinary interpretation of biological and behavioral development during adulthood. Therefore, the prognosis for this conceptualization of functional age appears favorable, at least until such time that sufficient research is available to reveal any unforeseen difficulties with this approach.

SUMMARY

Although chronological age is an extremely powerful index for characterizing average trends in performance, it is much less useful for making predictions about a specific individual. Concepts like functional age have been developed in an attempt to extend knowledge about group trends to the level of the individual. Among the particular questions one might like to have answered are: Can this person handle this job? How much longer can this person be expected to live? And what is responsible for the changes that have occurred to this person over his or her lifetime?

It has been suggested that the preceding three questions exemplify the major categories of research conducted under the rubric of functional age. The categories can be easily distinguished (see Table 1 for a summary of their major characteristics), but the failure to do so in the past seems to have led to much confusion and lack of real progress. Future research in this area should recognize, and consider separately, the multiple definitions of functional age. At the present time, the occupational concept of functional age does not appear useful, but both the biomedical and structural conceptualizations are promising and should be pursued in further research.

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