

## CHAPTER 1

### Introduction

# Chronological Time and Chronological Age: Problems of Temporal Diversity

*Jan Baars*

It is the aim of this volume to revitalize the debate about the concepts of time implicit in the study of aging. A potentially interested but already overburdened reader may wonder whether one needs or whether there is a need for such a book. Time seems such an ordinary unproblematic topic that a work devoted to it might appear to be a digression from many pressing problems of aging. Indeed, aging can lead to many problems that must be taken care of. This has put an enormous pressure on the gerontological community to provide or seek practical applications and solutions. It is not important to read this book so as to counter-balance such practically oriented work. Its importance is the exploration of real issues concerning temporal concepts and approaches to aging: whatever concepts of time are used determine to a large extent the way aging is approached.

There is a seemingly self-evident time that we read on clocks and calendars and use to determine the ages of cars, buildings and (why not?) human beings. This *chronological* time serves many purposes well but is actually quite problematic when it comes to aging, especially when it gets more credit than it deserves. That aging is poorly indicated by higher chronological ages may often be admitted, but this does not appear to lead to much change in research practices. The vast majority of studies of aging still use a chronological approach to define populations for research purposes (determine who the “aged” are that should be studied) and try to establish how (social, economic, health, etc.) characteristics of people change as a function of their chronological age. This may lead to an accumulation of data, but in itself not to *explanatory* knowledge.

2 / AGING AND TIME

The issue at stake is not whether chronological time should be abandoned; that would be to neglect the role it has to play in every empirical study, also of aging processes. There is, however, an unreflected overemphasis on chronological time that leads to problems, as if the precision of chronological time would in itself give a solid foundation to the study of aging. This idea is even more tempting as this concept of time has been institutionalized to measure and coordinate processes and actions all over the world, leading to a calendar that makes it possible to localize anybody's birth in time and precisely determine his or her "age." The grand ambition of gerontology still seems to be to establish how this chronological or calendar age of persons determines the characteristics of aging persons or even of all humans. This would eventually reduce gerontology to a straightforward set of simple formulas in which scientific precision and practical use would be united. Almost 50 years ago this option was already stated with much self-assurance: "Chronological age is one of the most useful single items of information about an individual if not the *most* useful. From this knowledge alone an amazingly large number of general statements or predictions can be made about his anatomy, physiology, psychology and social behavior" (Birren, 1959, p. 8). Although the author of these lines has later expressed serious reservations about them, a large part of the gerontological community is still under their spell.

One of the practical issues at stake is whether gerontology does not, in its search for clear links between age and characteristics, reinforce conventional generalizations about aging and the aged. Furthermore, even unfounded generalizations about categories of people with certain ages can be implemented in policies regarding, for instance, specific forms of care or housing for "the aged" and thus contribute to a reality which forces aging people to fit in, because there are no other options offered. Consequently, later research can affirm the earlier generalizations, not because they grasped the realities of aging, but because gerontological expertise has again played its unreflected role in co-constituting the realities of aging. In such cases, the analytical apparatus of gerontology runs the danger of becoming an uncritical instrument catering to all kinds of organizational contexts, in which aging people are mainly relevant as the subjects of planning procedures and average estimates. Such bureaucratic operations may be necessary, but should not dominate the way aging is approached or understood. Although aging processes can be measured chronologically, they are not regulated by chronological time. The step from chronological time to chronological age should be taken very cautiously if we want to take aging processes seriously, especially because chronological age is widely used in contemporary societies to regulate all kinds of processes with many consequences for the people concerned (see Baars, this volume). To counteract these tendencies, it is good to emphasize that the search for aging characteristics based on chronological age has established much counterevidence, testifying to the many differences in aging processes. This counterevidence comes hardly as a surprise when we try to imagine persons with the same chronological age but living in very different circumstances. Think,

for instance, of 60-year-olds: one would expect enormous differences in terms of empirical data and personal experiences between, let us say, a contemporary poor African woman, a Japanese man, or a homeless American of that age; not to mention 60-year-olds in prehistoric times, in the Roman Empire, in classical China or among nineteenth-century factory workers. The fact that in Western Europe the average life expectancy for males has practically doubled in the last 150 years (Imhoff, 1981) implies that chronological age cannot by itself give any precise reference to (a phase of) aging processes.

Chronological definitions of life expectancy must presuppose more or less regular cycles of human life in specific historical contexts. But also within the *same* historical period, different socioeconomic and cultural contexts, gender, genetic codes, medical histories, and individual choices or fates have been shown to be statistically associated with different aging processes. Even a “cohort identity,” established by contrast with other cohorts within the same historical context, remains to a high degree an abstract construction which has to tolerate a considerable amount of internal differentiation. Major longitudinal studies like the Berlin Aging Study (Baltes & Mayer, 1999) or the Seattle Longitudinal Study (Schaie, 1996) offer many examples of these differences (cf. also Daatland & Biggs, 2004).

Because human beings with the same chronological age can show, even from a mere biological point of view, very different aging characteristics, we can no longer assume that aging processes develop in synchrony with chronological time. As organisms age at different rates and even different tissues, organs, and organ systems within an organism may age at different rates, chronological age turns out to be even a poor predictor of remaining life expectancy, leading here and there to other directions for research, such as the quest for “biomarkers” of aging (Sprott, 2002). The many faces of aging between the extremes of a teenager suffering from progeria and a vibrantly alive centenarian are mirrors in which the hidden and profoundly puzzling varieties of aging as living in time stare us in the face. Maybe the many different processes of aging all have their own dynamical properties, but these may include, to make it even more complicated, an openness to the environment. These processes must be discovered in their *specificity*, and in the course of this discovery chronological time can only function as an instrument and should not be extended to represent a chronological age with an implicit gerontological surplus. Chronological age is only the amount of chronological time that has passed since somebody was born.

To avoid any misunderstanding, these arguments are no denial of the finitude of human life, nor do they deny that aging can be observed in any human being, if we compare characteristics of the same person over a relatively long period of time. The question is how to approach these themes to get a better understanding. To achieve this, it is essential to understand the specific significance and relativity of chronological time and its unfounded seductions in relation to aging.

### **A MISTAKEN IDEA BEHIND CHRONOLOGICAL AGE: TIME WORKING AS A REGULAR CAUSE**

Generalizations about people with a certain calendar age actually presuppose a *causal* concept of time: because time has worked for a certain duration in aged people, certain inevitable effects should be reckoned with. Moreover, the effects are assumed to develop steadily and universally according to the rhythm of the clock. However, such a causal concept of time in aging can never generate knowledge that might explain something of the differences that exist between human beings of the same age, nor allow us to understand that aging is a generalizing concept that is actually composed of many specific processes. While it is true that all causal relations are *also* temporal relations, or relations working “in time,” it would be wrong to identify causality with time or to reduce the process of aging to the causal effects of time. The same Jim Birren whose high expectations of the predictive power of chronological age I quoted earlier, has later dealt with time extensively and articulated a similar view: “By itself, the collection of large amounts of data showing relationships with chronological age does not help, because chronological age is not the cause of anything. Chronological age is only an index, and unrelated sets of data show correlations with chronological age that have no intrinsic or causal relationship with each other” (Birren, 1999, p. 460).

The elusive concept of time is usually made visible and calculable using *spatial* and *numerical* projections to explain what time is or how time works. A well-known example of such a spatial projection is drawing a straight line, which visualizes the time which is passing even during this action of drawing. This can easily be transformed into the “arrow of time” or into one of the axes in a diagram explaining changes as a function of time. But this visualization creates precisely the illusion that aging processes can be clearly and unequivocally related to chronological time. An important limitation of such projections is that they can clarify only those aspects that time has in common with space. But is it at all possible to concentrate on pure time as such and measure it precisely?

### **THE ABSTRACT RHYTHMS OF CHRONOLOGICAL TIME**

Time is usually indicated by clocks, which make it possible to measure the duration of a process or locate an event (the birth of a baby, a future appointment) in time. We know that some clocks do not function well, that they are not precise. But how can we determine whether a clock really measures time as such? Usually, we establish the accuracy of a clock by comparing it with the clock of an institution with “more authority,” such as the telephone company or television. But again, how can we determine the accuracy of such an authoritative clock? To what most “authoritative clock” or most “fundamental time” are these clocks attuned? To the movement of the earth around the sun? Is that time in an ultimate sense? Or

something else? Unfortunately, following this line of questioning does not lead to ultimate time or an ultimate clock. In all chronological time concepts that we know of, a specific, more or less regular process has been selected as a standard to establish what time is. In most traditions, the movements of the celestial bodies have been taken to represent time: defining years, seasons, months, day and night, hours and minutes.

But in principle, there are many processes that might be used as the basis of a chronological time concept. In fact, all rhythms could be taken into consideration. But a *general* time concept must be based on processes that cannot be influenced by the different processes it should measure. Therefore the movements of the earth and the moon were excellent candidates to form the basis of a general time concept, as their regular movements are clearly independent of anything happening on earth. But eventually this way of defining time resulted in many problems of measurement since these basic cosmological movements turned out to be too irregular. The elliptic form of the movement of the earth around the sun and the precession of the equinoxes caused, in the long run, a lack of precision in the Holy Calendar, which already upset the Pope toward the end of the fifteenth century and urged the Church to have the Christian calendar improved; changing it in 1582 from the Julian to the Gregorian calendar. After this, the calendar has more or less been left to itself as human beings could live very well with small, long-term irregularities; but these were increasingly regarded as intolerable to the degree that ever more precise measurements became of vital importance to further the range of effective control over nature. Therefore the search has been intensified for still more delicate regular movements that could be used as a basis for a general standard to measure all other movements.

The technical criteria that must be met have become extremely demanding. To be able to establish a natural process as a standard for measuring time, we need a periodic process with extremely short phases, which can easily be reproduced and has outcomes that are highly stable with respect to possible external disturbances. In searching for this time standard, the frequency of the periodical processes has risen to the level of the cesium atomic clock, which is based on a cycle of over nine billion vibrations during one (old) astronomical second. This has become the basis of the International Atomic Time, which is continuously broadcast from stations in Colorado (U.S.), Rugby (U.K.), and Braunschweig (BRD) and is received by the authoritative clocks referred to above. On this atomic foundation it is, in principle, possible to make chronological measurements extending from the millions of years that astrophysicists work with to the nano-seconds that are needed in other areas of physical research.

This time is indicated precisely by the clock, but this is in no way “time as such.” Its foundation is only a specific stable movement that has been selected to function as a standard for chronological measurement. It is only a very sophisticated convention that enables time to be measured by offering a precise instrument everyone can use for the abstract temporal coordination of their actions.

6 / AGING AND TIME

An important implication is that the constructed chronological concept of time, to be able to measure all possible processes (except its own), must be totally devoid of any content and be completely abstract. This abstract nature implies that of any process, only those aspects are relevant that can be measured according to this chrono-logic. All other possible aspects are neglected: the measurement of time has nothing to do with its meaning. The anthropological paradox is, however, that the chronological subject is *theoretically* completely detached, but *practically* necessarily involved in time.

That gerontology is seduced to let chronological age play such an undeserved prominent role has something to do with this paradox, which leads to specific problems of studying aging as living in time.

First, it is impossible to study processes of aging as we would study other processes because we cannot observe aging in an experimental group and compare the results with a control group that does not age. We are, like everything that exists around us, embedded in time and although (unlike stones or trees) we can be aware of this, we cannot step out of time or aging to observe it purely. Getting a clear understanding of time is hard because it is always difficult to distance ourselves from what we take for granted. Time slips away *because we are living in time* and cannot distance ourselves from it. This fundamental human condition, discussed in this volume by Jan Baars, leads to problems in even the most sophisticated research strategies. The notorious Age-Period-Cohort problem, which is addressed here by Warner Schaie, is just another example of the *enveloping* and *elusive nature* of time: we cannot step out of time to pinpoint it clearly. We can never find aging in a pure form: aging can only be experienced or studied in specific situations that influence and co-constitute the processes that are involved.

Second, we have no organ to perceive time like we can see objects in space. And although what we can see for ourselves may often seem self-evident but actually be self-deceiving, grasping time is even more difficult. Therefore spatial or metric figures are mostly used to represent time, but they already presuppose specific ways of dealing with it.

Every step in studying or even discussing aging already involves metaphors, images, or vague ideas about time, and they make an uneasy contribution to the results of these studies or discussions. Moreover, as aging involves many different processes at different levels, all these processes must be precisely understood in their own temporal qualities, which requires adequate theories and concepts. Because time and aging cannot be perceived directly, the dynamics of aging cannot be grasped without concepts. More clarity about concepts of time should be a major priority for gerontology because only if we can specify more precisely the nature of different aging processes will it be possible to arrive at better explanations of the variations in aging among humans of the same chronological age, which are often hidden in average scores.



A further exploration of the implicit concepts of time and aging appears not only to be important for most individual disciplines which study aging, but is certainly relevant for the interdisciplinary pretensions of the endeavor called gerontology. During the last years, there have been some important publications that have advanced the interdisciplinary theoretical debate in gerontology (e.g., Bengtson & Schaie, 1999), but it may be also fruitful to focus on a common theme such as time, which poses fundamental questions for all disciplines involved.

Apart from the scholarly virtue of furthering such a thematic interdisciplinary dialogue within gerontology, it appears that the only way to explain processes of aging lies in the study of the interrelations between the different temporal dynamics that are responsible for the heterogeneity of aging processes (see Visser, this volume).

Hendricks and Peters (1986), building on earlier work by Maltz and Riegel, distinguished chronological, individual, social, and ideational time; and parallel with these, inner/biological, individual/psychological, cultural/sociological, and outer/physical dimensions of time. These dimensions can be recognized in the contributions to this volume, which focus as a whole on methodological and epistemological aspects of time and aging.<sup>1</sup> The psychological, methodological, physical, and biological contributions are positioned between two chapters in which concepts of time and aging are approached from a broader metatheoretical perspective. The opening chapter by Jan Baars articulates the fundamental issues from the perspective of social theory, emphasizing the need to acknowledge three different approaches to aging and time. The final chapter, by Henk Visser, counterbalances this by analyzing the problem of interdisciplinary integration from the perspective of the philosophy of science.

### INTRODUCING THE CHAPTERS

Chapter 2, by Jan Baars, includes sociological and philosophical perspectives as he combines a theoretical reflection about concepts of time with a reflection about their possible practical consequences for aging persons. The overemphasis on chronological time and age is set against the background of cultural developments in which chronological time tends to become the only *shared* temporal perspective, as inspiring narratives about aging as living in time are largely absent or fragmented. As chronological time is only partially adequate in an empirical sense and completely inadequate to grasp the meaning of aging, Baars seeks both in a personal and a broader cultural sense to revitalize other temporal perspectives. He reflects on a major debate in Western philosophy, arguing the importance of subjectively experienced time in opposition to objective, chronological time. The

<sup>1</sup>However, aging as living in time poses many problems of a more existential nature, which are often referred to but not elaborated in this volume. They are addressed in a more recently started project (cf. Baars, 2002, 2005).

8 / AGING AND TIME

ambition of both perspectives, represented in the briefly cited main positions of Aristotle, Augustine, the phenomenologist Husserl, and the existential philosopher Heidegger, has been to constitute time *as such* from their perspective. From the confrontation between these theoretical positions, which are still basic for contemporary thinking about concepts of time, it follows that the ambitions of both traditions to constitute the one and only essential time must be seen as a failure: *both* objective and subjective time are necessary. They cannot constitute each other's perspectives. Moreover, it becomes clear that a third temporal perspective is presupposed and must be acknowledged in its own right to allow a more adequate understanding of aging as living in time: narrative articulations of shared meaning.

Baars argues that in order to do justice to the complexity and meaningfulness of human aging, gerontology should be guided by a meaningful configuration of three fundamental temporal perspectives: chronological measurements, personal experience, and narrative articulations of aging as living in time. They should each play their own explicit role in a Triple Temporality of Aging.

In Chapter 3, Elke van der Meer presents an overview of the most recent results from cognitive research and brain-based research on psychological time. From this overview we can learn that temporal experiences are not only conceptually mediated, but also presuppose memory structures and processes in the "hardware" of the human brain. The chapter presents another fascinating encounter of the objective and subjective time Baars writes about, as experimental research proceeding with objective, chronological time is used to clarify the subjective experience of time. Van der Meer discusses temporal order (succession) and temporal duration and also the temporal perspective (past, present, and future) which is presupposed in viewing human lives diachronically. We can see how Augustine's ideas about the subjective mind that embraces past, present, and future have already captured some of the temporal functions of the brain.

Whereas Augustine, however, assumed the human mind to be without age, it has been amply demonstrated that time concepts are gradually acquired through childhood and that there are important differences between young and older adults in the ways they look at past, present, and future. As humans are living through time, their bodies are aging and their brains are also changing. On the one hand, the brain is an organ like other organs, but on the other hand its high level of differentiation and complexity once again precludes a simple formula: the aging of the brain does not proceed according to chronological age. Not only do different regions in the brain like the hippocampus, cerebellum, and prefrontal cortex play their own intricate roles, but cognitive functioning represents a complicated temporality of its own. Van der Meer emphasizes that there are many possible factors influencing cognitive functioning and that its decline is neither linear nor irreversible as regional dysfunctions can be overcome by compensating mechanisms, so that cognitive aging becomes a mixed process of change, gains, losses, and maintenance (cf. Baltes & Singer, 2001; Park & Schwarz, 2000). In



this context, van der Meer discusses the possible reasons for the widely held impression that time seems to pass more quickly as we get older. Often this is explained by referring to an internal clock or “neuronal pacemaker” that might be running more slowly, resulting in the impression that “external” time moves faster. But maybe the experiences in childhood are more diverse and the years spent as aged persons are dominated more by routines, so that cognitive (and not hardware) components are constitutive of the experience that time moves faster, which also points to the relevance of age-structured social contexts.

Such cognitive components are explored in Chapter 4 by Freya Dittmann-Kohli, who delves deeply into the temporal perspective of the self, as she draws upon innovative research methods that integrate quantitative and qualitative approaches, allowing her to study large datasets. She shows that there is also a subjective experience of the temporality of the self who is living in time. During midlife, a different sort of subjective temporal perspective emerges, which focuses on the self as having limited duration and facing decline and eventual death. Also, in younger persons with a serious illness, it may happen that knowledge of mortality becomes more personalized and integrated into the cognitive structures of identity. This amounts to a cognitive integration of the basic facts of human life: being a person with a past, present, and future that may be unexpectedly short or very long but still limited. This awareness of the human condition leads, in many aging persons, to another view of time than they had before. A person who has been an ambitious achiever may develop a more hedonistic orientation toward the present, which is not a sign of shortsightedness or irresponsibility, but of wisdom and understanding of the value of the time that remains. This leads to such goals as continuity, preservation, and maintenance, which are different from the ones that are typical of the “achievement syndrome.” It turns out that the usual constructs of the Future Time Perspective are typical of healthy young or middle-aged adults and not representative of people who are seriously ill or very old or of people in cultures that are less oriented toward achievement and ambition. In contrast to traditional studies on Future Time Perspective, Dittmann-Kohli therefore emphasizes the importance of an *existential time perspective*, which develops as a cognitive framework or cognitive structure of identity in later life, as persons become more directly aware that they are living in a finite time perspective in which they are advancing, gathering more past, and facing less possible future. This experience of aging spreads gradually to all domains of life; there is an increased salience of existential time in late life—an awareness that an important part of life has passed.

In Chapter 5, Warner Schaie addresses the problems connected with the concepts of time and aging by exploring a methodological approach that can avoid some of the pitfalls connected with the so-called APC problem. The complexity of this problem can be illustrated as follows: when we have gathered data concerning a certain group of people we call aging or elderly, we cannot be sure whether these data tell us something about the aging process in general,

about the specific period of study, or about the specific cohort these elderly people belong to. A precise assessment of these three aspects evades us; they are all relevant but we don't know how. Almost 40 years ago, Schaie had already articulated this problematic constellation in terms of a "General Developmental Model," and his most recent methodological strategy is highly interesting and subtle. As the unconfounded estimation of all components of the APC, or General Developmental Model, still eludes us, it is important to find ways to break the dependencies in the model. One way is to redefine one of the components in such a way that it is no longer directly dependent upon calendar time. For this purpose, Schaie chooses time-of-measurement or period, the component that is concerned explicitly with the timing of events of interest to the researcher. By concentrating on events, chronological time becomes a dependent variable and "raw calendar time," as Schaie calls it, is transformed into something more meaningful: event time. Instead of beginning by gathering a population with a certain age, one can start by defining a transition (or maturational variable) and investigate specified characteristics (with their ages as just one option) of people who go through this transition. A methodological device called the "Cattell Cube" is called upon to construct an appropriate design for this analysis, which is differentiated further into substantive *type* of event, *impact* of event, *direction* of event, event *density*, and *perceptions* of the event. As Schaie notes, event density can refer to historical periods, maturational periods, or to an event density provided by the environment. Accordingly, event time can be constituted at several levels, including the chronological regimes that Baars is referring to, which define people as aged at a certain age and use ascribed characteristics of these persons to legitimize these regimes.

Next, there is a fascinating confrontation between Jos Uffink and Eugene Yates in the short Chapters 6 to 9, partly devoted to a debate that originated between them during the preparation of this volume. They introduce the ideas of authors, such as Albert Einstein, Niels Bohr, Max Planck, Ilya Prigogine, and Stephen Hawking, who have deeply influenced the way we look at the universe, into the discussion about time and aging. Uffink begins with reviewing basic conceptual issues concerning physical concepts of time, from which he proceeds to a clarification of some important issues such as time *scale*. Often but confusingly, a particular time scale is called a particular *time*, as if a different type of measurement would be the same as adopting a different time, although the underlying concept is still given by "the same qualitative temporal ordering," as Uffink writes. He distinguishes the *measurement* of time from its *meaning* and insists that even in theoretical physics the meaning of time still has to be grasped on the basis of everyday language or narratives. He denies that it would be possible to specify the meaning of time in terms of theoretical physics or to define time in terms of more fundamental, nontemporal notions. According to Uffink, we can learn a lot from physics concerning the measurement of time, but nothing regarding its meaning or subjective experience and very little about human aging. Thus he underscores the

remarks made about the empty and abstract nature of chronological time that were made above.

From this rather skeptical perspective, Uffink analyzes the work of some gerontologists who argue that theoretical physics provides an important clue to the understanding of aging, most notably Eugene Yates. Because the Second Law of Thermodynamics is often referred to in such endeavors, Uffink focuses on the problems of such applications of thermodynamics. The first problem that he notes is that aging cannot be understood as an accumulation of entropy or disorder, because a loosening of constraints as human aging proceeds is only one aspect, the other being that constraints may also change or new constraints may rise. To define aging as an accumulation of entropy turns this precise terminology into a speculative metaphor that serves no clear purpose. The second problem that Uffink notes concerns the use of accumulation of entropy as a theoretical foundation for a so-called intrinsic time/age, as opposed to a time/age that is measured externally, without being grounded in the specific dynamics of the system. If this would work at all (which Uffink doubts) there might be as many intrinsic times as there are aging systems (humans, organs) and we would lose the possibility of comparing or measuring them. Moreover, the openness of the human living system undermines the idea of an intrinsic age, which may be deeply influenced by changes in the ecological or social environment.

Uffink also discusses the spectacular Twin Paradox and its famous time dilation effect which would, however, only arise if humans would travel through the galaxies at speeds close to that of light. The Twin Paradox may be a fascinating possibility for elementary particles, but does not contain a feasible perspective for humans as long as they remain earthbound and are not subjected to traveling at speeds that are hardly imaginable nor endurable.

However, this fundamental difference between the elementary particles of conventional physics and the dynamics of living organisms is precisely what has encouraged Eugene Yates to develop his "Homeodynamics." Although he maintains that *biological* entities are ultimately *physical*, he is convinced that they cannot be adequately understood by standard physics. Whereas conventional physics focuses on inanimate physical systems and tends to abolish time, Yates is looking for a new heuristic perspective that can generate new approaches to the temporal qualities that are inherent in living organisms, building on fluid mechanics and the thermodynamics of irreversible processes. He argues that all multicellular organisms that reach a fixed size after a period of growth inevitably grow old and die; they live in irreversible or anisotropic time, which they generate and scale to an important degree through their own activities. We know from other research (e.g., Albrecht, 2002) that human bodies are temporally organized and maintained by periodic processes such as biological clocks. Many of these appear to be dominated by circadian rhythms, having originated in an evolutionary environment in which the solar system imposes 24-hour-long rhythms on life. Most physiological processes show such relatively independent circadian

rhythms, which are also maintained or disturbed by external “Zeitgeber” (time givers). Yates presents an elegant model in which gerontological discussions of age-related disturbances of such circadian rhythms can be connected to a dynamical process of aging from birth to death. He designs a helix in which the lifetime energy budget of humans is portrayed in the form of a truncated ellipsoid, thus making visible the gradually diminishing functioning of circadian processes over a lifetime: the lifetime energy budget is gradually used up. The homeodynamic cause of senescence is an accumulation of internal entropy, which displaces a system from its normal optimal operating condition of “orderly disorder.”

The goal of these explorations is to find an approach to aging processes that does not depend on external generalizations, but is based on aging processes operating within the living organism, so that we may better understand why people age differently when they share the same chronological age. Yates emphasizes that measuring the dynamics of these processes in terms of chronological time does not offer much more than an externally applied categorization of the intrinsic dynamics of life. He is searching, therefore, for a biological time in terms of the coordination of the internal actions of a living system, resulting in its internal temporal organization. The intrinsic dynamics generate the irreversible time that is characteristic of living organisms, so he concludes that “homeodynamic processes do not occur in time—they *make* their time.” The need to keep aloof from chronological age as an explanatory factor is again affirmed when Yates quotes from Barbour’s early work: “Physics must be recast on a new foundation in which change is the measure of time, not time the measure of change.” *Mutatis mutandis* could also be a motto for Schaie’s contribution.

Finally, Henk Visser looks back from the perspective of philosophy of science and asks what the preconditions might be for interdisciplinary research on aging, discussing some of the obstacles as well as possibilities. One of the obstacles he notes is that scientific concepts of aging are often derived in an unclear way from commonsense concepts or notions. He suggests therefore, investing more research in a data-oriented approach, instead of the operationalization approach, which is typically oriented toward taking over commonsense concepts, trying to transform them into scientific concepts.

Visser emphasizes especially the systematic significance of concepts in their function to make multilevel or interlevel explanations of aging possible. Although he remains rather skeptical about the present potential of gerontology to arrive at such explanations, he points pragmatically to the perspective of studying aging processes as changing possibilities over time, working gradually upward in a data-oriented approach from lower-order theories to more comprehensive theories.

## REFERENCES

- Albrecht, U. (2002). Invited review: Regulation of mammalian circadian clock genes. *Journal of Applied Physiology*, 92, 1348-1355.

- Baars, J. (2002). *Ouder Worden en de Fragiliteit van de Intermenselijke Conditie* (Aging and the fragility of the interhuman condition]. Utrecht: University for Humanistics Press.
- Baars, J. (2006). *Het Nieuwe Ouder Worden. Problemen en Perspectieven van leven in de tyd* (Aging in a new light. Problems and perspectives of living in time]. Utrecht: University for Humanistics Press.
- Baltes, P., & Mayer, K.U. (1999). *The Berlin Aging Study: Aging from 70 to 100*. New York: Cambridge University Press.
- Baltes, P. B., & Singer, T. (2001). Plasticity and the aging mind: An exemplar of the bio-cultural orchestration of brain and behavior. *European Review*, 9, 59-72.
- Bengtson, V. L., & Schaie, K. W. (1999). *Handbook of theories of aging*. New York: Springer.
- Birren, J. (1959). Principles of research on aging. In J. Birren (Ed.), *Handbook of aging and the individual: Psychological and biological aspects* (pp. 2-42). Chicago: University of Chicago Press.
- Birren, J. (1999). Theories of aging: A personal perspective. In V.L. Bengtson & K. W. Schaie (Eds.), *Handbook of theories of aging*. New York: Springer.
- Daatland, S. O., & Biggs, S. (2004). *Ageing and diversity. Multiple pathways and cultural migrations*. Bristol: Policy Press.
- Hendricks, J., & Peters, C. B. (1986). *The times of our lives*. In J. Hendricks & M. M. Seltzer (Eds.), *Aging and time. American Behavioral Scientist*, 29(6), 662-678.
- Imhoff, A. E. (1981). *Die gewonnenen Jahre*. München: Beck.
- Maddox, G. L., & Lawton, M. P. (Eds.). (1988). Varieties of aging. *Annual Review of Gerontology and Geriatrics*, 8.
- Park, D., & Schwarz, N. (2000). *Cognitive aging. A primer*. Philadelphia: Taylor & Francis.
- Schaie, K. W. (1996). *Intellectual development in adulthood: The Seattle Longitudinal Study*. New York: Cambridge University Press.
- Sprott, R. L. (2002). Biomarkers of aging. In D. J. Ekerdt (Ed.), *Encyclopedia of aging*. New York: Macmillan Reference.