AGING AND THE SUBJECTIVE SENSE OF TIME

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Summary

The paper deals with the possible interrelation between aging and the subjective sense of time. Three statements are under discussion:

1. As we age, universal age-related changes in an organism appear to slow down. So, the individual aging rate probably decreases with age in general.
2. The subjective speed of time is reversibly related to the rate of age-related changes in an organism. As we age, time „runs faster".
3. Age-related changes of the individual sense of time should be taken into account when effects of anti-aging treatments are estimated. The same real increase of the life span may be accompanied by a different subjective effect of the increase.

Keywords: Aging rate, Subjective speed of time.

Introduction

The goal of this paper is to discuss the possible interrelation between aging and the subjective sense of time. Firstly, a hypothesis concerning the possible dynamics of general age-related changes in an organism will be presented. Then, the age-related change of the subjective speed of time will be discussed in connection with the rate of general age-related changes in an organism. Finally, different approaches to estimate effects of anti-aging treatments, taking into account the change of the individual sense of time, will be suggested.

1. Hypothesis: The aging rate decreases with age.

If we define rate as a number of events per unit of time, then the individual aging rate may be calculated as a quantitative change of a biomarker of aging per unit of age in an organism. There are different opinions about typical dynamics of the age-related changes of a biomarker of aging. The change is shown to be accelerated, decelerated or linear, depending on the chosen variable [1, 2]. Correspondingly, the individual aging rate measured as described above may be assessed as increasing, decreasing or constant. Practically, too many variables are used as aging biomarkers in research: not all their changes may be really related to aging. Thus, the time (the duration) of the exposure of an organism to some factor may influence the changes more significantly than aging itself. Therefore, if we would like to share general trends of the aging rate dynamics, we should take into account only universal age-related changes in an organism, that is,

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occurrring during anybody's aging, regardless to sex, health, and longevity. Then it may be stressed, that the rate of such universal changes generally decreases with age, and the corresponding phenotypical effect of aging (the sum of the age-related changes) progresses with age at a slower rate. We'll illustrate this assumption by samples. Age-related changes of the following variables and traits: the metabolic rate, the rate of cell proliferation, physical and mental alertness, the skin elasticity, common age appearance etc. – are all universal, because the changes go in the same direction in anybody. Thus, the basal metabolic rate decreases during anybody's life to a slightly slower rate (**Fig.1**).

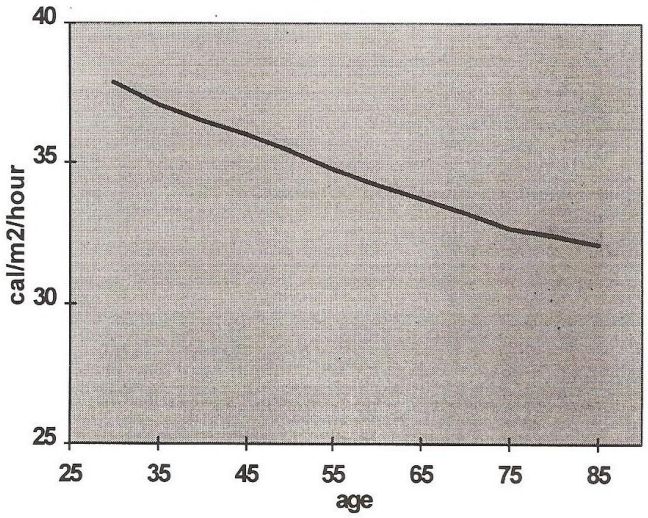

Fig. 1: *Human basal metabolic rate (adapted from [1]).*

The rate of cell proliferation also decreases with age universally [3]. Correspondingly, an organism grows with advancing age at a slower rate (**Fig.2**). The skin elasticity changes with age also at a slower rate (**Fig.3**). The age-related deceleration of the effects of aging also may be noted at the level of the general aging phenotype, like the common age appearance (**Fig.4**). As we age, visual changes we perceive appear to „slow down". Thus, a 60 year-old person visually is more different from an 80-year-old one, than an 80-year-old person is different from a 100-year-old one (by the general aging phenotype). One can say, that older people grow old slower than younger ones. If the increase of phenotypical effects of aging generally slows down with age, it may lead to some stabilization of functional parameters of an organism at

older ages as shown in **Fig.5** reflecting a possible interrelation between the chronological age and the phenotypical result of aging.

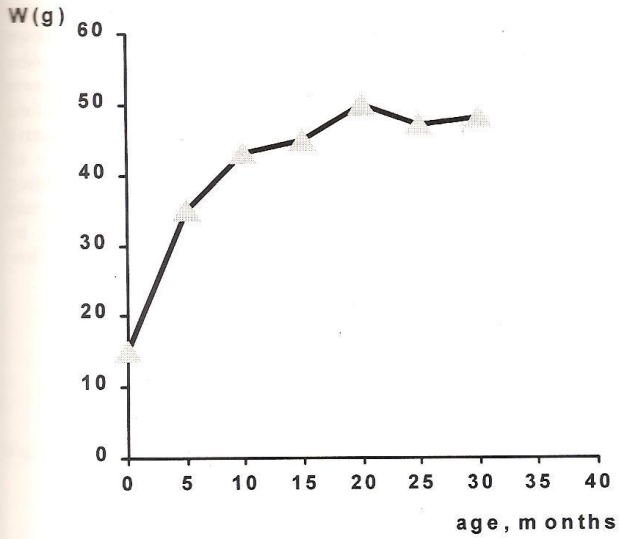

Fig 2: *Age-related changing weight in ad libitum fed mice (adapted from [4])*

First conclusion. Taking into consideration only universal age-related changes in an organism (i.e. typical of anybody's aging, regardless to sex, health and longevity), it may be noted that the rate of the changes generally decreases with age, and the corresponding phenotypical result of aging progresses with age at a slower rate.

2. The subjective speed of time changes with age.

As may be concluded from what has been reported above, the general aging rate in an organism probably decreases with age. Simultaneously, the individual sense of time also changes. Together with the age progress, time subjectively "runs faster". Thus, a month seems shorter to an adult than to a child. Some psychological observations showed, that time seems more swift to old persons (about 70 years of age), than to younger adults (about 20 years of age). And on the contrary time seems more static to younger people than to older ones. An explanation of this phenomenon suggests that the older subjects value time more highly than the younger ones.: the young people potentially have more time ahead of themselves, and so appreciate it less [7]. We believe, hovewer, that the subjective speed of time is more connected with the rate of

biological processes in an organism, e.g. the metabolic rate, the rate of cell proliferation, physical, mental alertness, and the rate of living in general. A slower rate of living means that less events pass per unit of time in an organism, and more time is needed for an event. Correspondingly, the efficiency in the use of time decreases, and the subjective speed of time flow increases. For example, the nerve impulse conductivity slows down at an older age. It is accompanied by the slower thinking process in elderly. An older person needs more time for the same mental action than a younger person. The slower the thinking process, the faster time runs for a subject. Therefore, the speed of time seems to the elder higher, than to an adult or a child. One can say, that the subjective speed of time is reversibly related to the rate of general age-related changes in an organism („the rate of living"). The higher the rate, the slower time flows for a subject. The less the rate, the faster time runs for the subject. Simplifying, this phenomenon may be named as a case of „ time relativity" for humans (and possibly for animals), by analogy with the main point of Albert Enstein „the time relativity theory": the time flow rate in a physical body is reversibly related to the rate of moving the body.

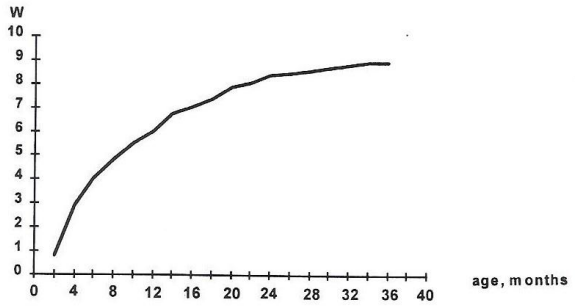

Fig.3: *Age-related changes of the tail collagen contraction in rats (adapted from [5]).*

If the subjective sense of time naturally changes during the life of an individual in connection with the rate of age-related changes in an organism, then people of the same chronological age may have a different individual sense of their own age, because people may be different in their individual aging rates. The «subjective age» of a person may be calculated as the mean age disposed between the real ages of people, who seem to the tested person as younger and older than the person is. The sense of such estimations is the following: when we are 20-years-old, we accept a person who is 35, as older than we are (by common age appearance). When we are 50, our inner perception of the same age (35) is changed, and a 35-year-old person seems to us already younger than we are. The change of perception of age is typical of every person that is getting old. That is, our inner perception of the age of other people changes along with our own age progress universally. So, the change may reflect basic traits of the aging process. And «the subjective age» may be used as a candidate biomarker of aging.

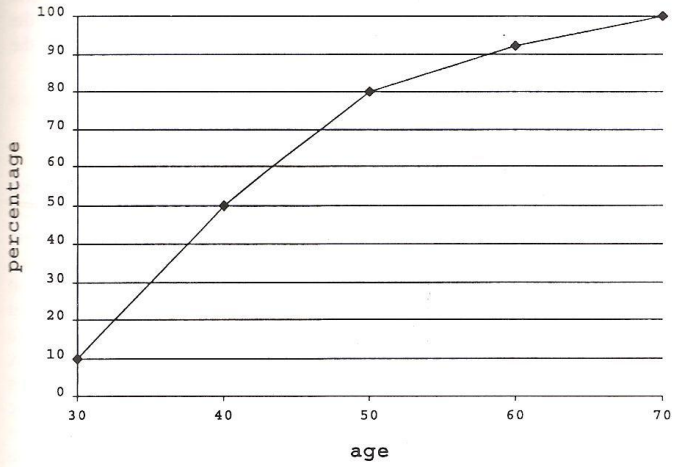

Fig. 4: *Rate or hair graying for 3872 Australians (adapted from [6]).*

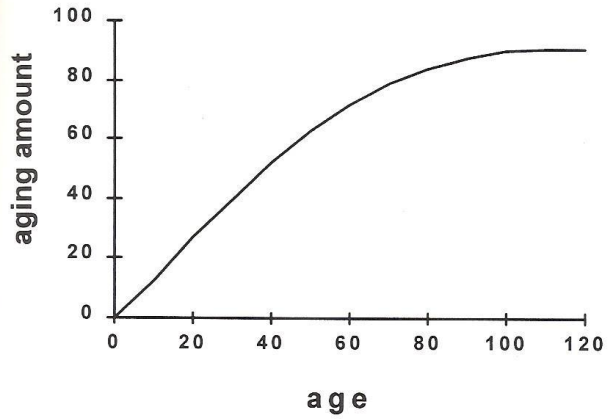

Fig. 5: *Hypothetical interrelations between the age and the sum of aging-related changes in an organism.*

Second conclusion. The subjective speed of time is reversibly related to the general rate of age-related changes in an organism („the rate of living"). The higher the rate, the slower the time flows for a subject. The lower the rate, the faster time runs for the subject.

3. The change of the subjective sense of time is essential for the estimation of the efficiency of anti-aging treatments in humans.

The main practical goal of gerontology is to develop an effective anti-aging treatment. A number of substances have been discussed as geroprotectors (drugs, that postpone aging), especially neurotransmitter-related ones. Thus, several dopaminergic and serotonergic medicines appear to have properties of geroprotectors. They were shown to lead to increasing both the mean and the maximum life span of experimental animals. And it is noteworthy that these drugs prolong the life span by quite different ways. Thus, dopaminergic geroprotectors (e.g. L-DOPA and deprenyl) increase the life span of mice as well as the physical and mental alertness [8]. On the contrary, serotonergic geroprotectors (e.g. melatonin and epithalamin) prolong the lifespan alongside with some sedative effects [9]. On the whole, dopaminergic and serotonergic geroprotectors display some antagonism of action in an organism. The increase of concentration of one of them in the brain is usually accompanied by the decrease of the other. Thus, long-living people from Abkhasia, Georgia, and Ukraine have signs of high dopamine and low serotonin levels in their brains [10]. Low-tryptophan-fed rats were age-delayed and simultaneously showed a decreased serotonin (but not dopamine) level in some parts of the brain [11].

So, approaches to postpone aging may be quite different and sometimes opposite. On the one hand, anti-aging treatments may be accompanied by mental and physical intensification, and by increasing the whole living activity („rejuvenation" effect). On the other hand, they may be accompanied by a decrease of the metabolic rate as well as mental alertness and by decreasing the whole living activity („aging retardation" effect). The influence of an anti-aging intervention on the subjective sense of time may be also different [12]. Thus, if some geroprotector leads an organism to the metabolic parameters typical of younger ages along with an increase of the living activity and so the efficiency of using time, then the anti-aging treatment may be accompanied by a subjective effect of life span extension, even without actual increase of the life span. On the contrary, another geroprotector may prolong life along with a deceleration of the whole living activity in an organism. But, as was mentioned above, the rate of living in an organism appears to slow down with age without any treatment, in a natural way. The geroprotector may overslow down this process. Correspondingly, the changed subjective sense of time ("time runs faster") may neutralize the effect of the real life span extension. For example, after the course of such anti-aging treatments, a patient may get some feeling, that two days run like one day before the treatment. The subjective effect of the life span extension may not take place in this case.

Third conclusion: Using geroprotectors, we should take into account the natural change of the subjective sense of time during a life, as well as the possible change of the

sense of time after an anti-aging treatment. Different methods of aging postponement may be accompanied also by different types of changes of the subjective sense of time. The subjective effect of the treatment may be affected by these processes.

General conclusion

A hypothesis was suggested about a possible interrelation between aging and the subjective sense of time. The hypothesis includes three aspects. First, we supposed that the rate of age-related changes in an organism generally decreases with age, and general effects of aging are accumulating at a slower rate. Then, we supposed, that the subjective speed of time is reversibly related to the general rate of age-related changes in an organism. As a consequence, time „runs faster" with age. Finally, we discussed the possible influence of change of the individual sense of time on the subjective effect of anti-aging treatments. We suggested to take into account the fact, that different methods of life span extension may be accompanied also by different changes of the individual sense of time. THE subjective effect of aging postponement may be affected by these processes.

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