A Psycho - Physiological model of longevity

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For a long time now wear and tear has been around in gerontology as one way of explaining aging differences and differences in longevity, i.e. why different persons age with different speed and why some people live longer than other even up to 100 years of age or more. Today I want to present some ideas and data that support this notion. So I will talk along the following themes :

Pic 1 The synopsis

Pic 2 Wear and tear

Wear and tear was first formulated as a theory of aging by Weismann in 1882 as the Abnutzungstheorie, states that the replacement of damaged or worn out parts, is not perfect enough or does not occur at a rate sufficient to compensate for the deleterious effects of time. In modern times the same idea was reflected by Kirkwood and others (1979) in the "disposable soma theory" that predicts the accumulation of unrepaired damage through life, senile degeneration ultimately death.

The mechanisms that I propose to be responsible for these processes is the lifelong exposition to stress and strain that, when being excessive to the capacity of the individual, promotes premature aging in a similar way as implicated in the wear and tear theories.

And I hope today to present a convincing case for such a mechanism as one of the major factors explaining the aging variability.

There are some indications in research that we can use as a starting point for such a discussion.

First indication.

Pic 3: Why don't we see so many old salmons?

My house where I live is situated on an island and a cross the straight on the mainland there is a river. To this river comes a great number of salmons for reproduction each year. They make a heroic struggle up the river to come back to were they were born to spawn and then most of them die. So we can as Sapolsky ask: Why does we not see any real old salmons?

The answer is a bolting secretion of glucocortocoids. The excessive stress, struggling to return to their spawning grounds has caused structural changes in vital organs (such a s kidneys, adrenal glands, collapse of immunological defence causing infections and attacks of parasites and micro-organisms.) The brain has eventually lost its ability to regulate the amount of stress hormones circulating in the blood and order the glands to produce more and more with disastrous consequences. On the contrary, a salmon caught after spawning and with the adrenal glands removed will survive. Sapolsky conclude from this example that it is the excessive stress that cause the premature death.

Second indication

Pic 4: The general adaptation syndrome

The prototype for this reaction chain is the classic Selye experiment (1946). Selye shows that during long-lasting stress, adaptation requires excessive use of the autonomous and endocrinological systems and that leads to structural change that reduces future adaptive capacity. Adaptation is a chimera or a pseudo-adaptation and with continuos exposure to stress and strain, such amounts of endocrine resources are required ("to keep up appearances ") that the systems will deteriorate and its function will be seriously depleted. In this situation and if the individual is exposed to further stress, the systems are exhausted, resistance is low, and the capacity for adaptation is lost making the individual susceptible to the onset of diseases that might even be life threatening To cite Selye himself (1970): "Many of the characteristics of the stage of exhaustion are strikingly similar to those of senility. It is tempting to view the general-adaptation syndrome as a kind of accelerated aging." Transferred to human behavior man is specially well equipped to adapt or pseudo-

adapt to most extraordinary circumstances which might be contraproductive with regard to longevity.

Third indication

Pic 5: “The burn out” syndrome

“Burn out” is today in Sweden the most rapid increasing diagnosis leading to sickleave from work and employment. Symptoms are exhaustion, depression, anhedoni, lacking empathy and in its aetiology is usually found be excessive stress exposure for a considerable time.

Pic 6: Indications of “burn out” (1-5)

(1,2.) It is especially prevalent in high performing women (3) and it is also given as one of the explanations to the decline in survival time for the Danish women.
(4) Swedish researchers, Berglund and others, have found that for individuals with a number of burn out episodes during life it was found that the vascular structures were prematurely aged and incidences of vascular diseases increased. (5)

Fourth indication

Pic7 : The allostatic load
The price of adaptation – the worse the situation the higher the cost.
In the MacArthur Study of Successful Aging, Seeman, et al., (1998) used the term Allostasis or Allostatic load as a summary concept for a number of physiological parameters (such as BP, HDL cholesterol, LDL cholesterol, cortisol and DHEA etc.) to study the effects or the consequences of enduring exposition to stress and strain to the individual.

Pic 8 : What is allostatic load?
In their definition, allostatic load "refers to the physiological wear and tear on the body that results from an individual's ongoing effort to adapt to the world around him ” It was concluded that allostatic load as an index of wear and tear predicted an increased risk for a

decline in cognitive and physical functioning as well as cardiovascular disease in older men an women . McEwan & Stellar (1993) use the concept and define it as the sum of **"**the strain on the body produced by repeated ups and downs of physiologic response, as well as by the elevated activity of physiologic systems under challenge"

A psycho-physiological model of aging

With these considerations in mind, it is possible to construct a psycho-physiological model of aging that in a life-span perspective will explain, how psycho-physiological interaction can determine the variation in functional capacity among the elderly. An extensive empirical support for the validity of such a psycho-physiological model of aging has been reviewed previously by myself in a number of publications and will not be repeated here.

Pic9: An aging metaphor - life-span as a car race

To understand the interaction over time we can think of the life span as a car race. Thinking through the components in such a metaphor would show a great deal of similarity to most of the longevity predictors that we today know from research. (The quality of the car _ heredity, the fuel - nutrition, the drivers behaviour - personality, the company – social relations, the maintenance – regular health check ups and so fort)

So taken together, results so far make it reasonable to assume a relationships between life experiences, individual resources, physiological responses and variation in aging. The psycho-physiological model proposed here attempts to further elaborate the mechanisms behind this association as the individual is exposed to it during a life time.

Pic 10. The psycho-physiological model

The basic proposition for such an explanation is as follows: Functional differences in old age are the result of life-long exposure to the environment and to an individual's method of managing the environment as a function of his unique personality, psychological, and biological characteristics. Furthermore, the unique characteristics in the personal disposition will be decisive for the perception and handling one's life situation. During the lifetime, these habits, in accordance with a wear and tear paradigm or a constructional development paradigm, will eventually result in

functional capacity differences in old age. Hence this psycho-physiological model was formulated.

The model has two entries: one behavioral shown in blue boxes, and one physiological, shown in yellow boxes. The behavioral side deals with lifelong positive and negative experiences, immediate psychological reactions (state), habituated psychological structures (traits) and psycho-somatic interaction. The physiological side deals with short-term reaction in the autonomic and endocrinological systems (allostasis) and long-term reactions such as wear and tear, oxidative stress, and psychosomatic unity. The process is affected differently depending upon individual vulnerability (genetic inheritance, etc.) and sensitivity to environmental stimuli. This developmental process takes place in a social and ecological environment. To various degrees, the process affects a number of outcomes such as longevity, functional aging and well-being in old age.

In the blue boxes we can see the psychological components that in the short term perspective give raise to immediate reactions such as anxiety and pressure or pleasure and wellbeing, which when repeated during long enough time will habituate personality characteristics and adaptive patterns that will be decisive for future person - environment interaction.

In the yellow boxes we see how short term physiological reaction by repetition effects structures that have a negative or positive outcome on bodily functions according to our knowledge from the psychosomatic research field.

Not momentarily but as a result of exposure during a long life to the combined effects of daily experience and physical reactions it will show at the end of life as a variation primarily in functional capacity. *Gutta cavat lapidem non vie sed seipe cadendo* (dripping sets its mark not by force but by enduring repetition).

Pic 11 Young and old endocrinological system

To be a little more technical I have to point to the focal point in this model.

Central for understanding the wear and tear mechanism is the activity in the HPA system (hypothalamus – pituitary – adrenal stress hormone regulating system) It has a high resilience in young age but it is with age effected by the psychosomatic interaction in a way that makes it both self-destructive and with deleterious effects on bodily functions i.e. accelerates the speed of aging.

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Comparing the young and the old HPA axis reactivity especially with regard to the recovery efficacy after being exposed to stress we find evidence of first of all a defect breaking system in the hypothalamus area which make the flow of cortisol long-lasting and uncontrollable.

Second we can see the consequences, a long-lasting exposure in the body of active stress hormone,

a s. c. cortisol tail has been created, the older the person, the longer the tail.
Both kinds of dys-regulation having negative effects on the functional abilities in the elderly, and the older the person, the more sensitive he/she is to the effects of the HPA dys-regulation.

Testing the model.

Pic 12: SNAC-B

In a first test of the model, functional performance was chosen as outcome and stress reactivity was chosen as a causal factor.
From an ongoing project, SNAC-B, studying elderly between 60 and 96 years of age variables depicting elderlies performance ability were chosen to create a functional index. Examination and assessment of the subject was used to induce experimental stress in the subjects and cortisol in saliva were measured before and after stress exposure. The difference in cortisol secretion was used as a marker for stress reactivity.

From the model could be deduced the following hypotheses:
First: The lower the functional capacity the higher the stress reactivity.
Second: This relation should increase with age if excessive stress reactions are a marker for premature aging
Third: The older the subject in terms of function, the longer the time for the hormonal system to return to equilibrium.

Results show two things: Up until 78 years of age their is a positive correlation between function and stress reaction , meaning that the better the function the more the stress. From 80 two 96 the opposite is true meaning the less the function the more the stress. What we see is how people as they grew older are more and more disturbed by inability while in young age stress is positive contribution to better performance. We can both see the increased stress sensitivity with increasing age and the increasing difficulty with reduced function to handle the physiological reaction i. e. return to resting state and an equilibrium.

Overall, the results seem to confirm the hypothesis of an increased stress sensitivity and reactivity with increased age. Assuming that the functional performance indices reflect the progressive ageing process, the data also lend support to the psycho-physiological model of ageing in the sense that premature ageing is the result of a reduced

capacity for the HPA-system to break the stress induced cortisol release. This causes a longer duration of physiological stress, the so-called cortisol-tail, which contributes to the "wear and tear" of the body and eventually might increase the speed of ageing.

The summary

Pic: 13 Summary

An elaboration of the old wear and tear theory can show some of the mechanisms that helps us under stand why people age differently.

Lifelong mismanagement of stress in all forms as well as an overadaptive behaviour seems to take its toll on the body when considered in a lifetime perspective and promote a premature aging.

I guess being human has the advantages of almost infinite capacity to adapt but an adaption that can be very costly in the long run

Pic: 14 Summary

The difference between us an the animal if we for a moment return to my salmons is that we as humans have a choice which the the salmon don´t.

Our choice is very much anchored in the personality characteristics that we develop during a life span.

And at the end of life it will show in the way we age.

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