Evolution of the Concept of Stress

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Rozanov, V.A. (2017). Evolution of the Concept of Stress, *Understanding Stress at Work*, 17-21. http//hayka-kultura.org/larsen.html

Hans Selye (1907-1982) has developed his concept of general adaptation syndrome (GAS) in 1936 as a universal biological mechanism of adaptation to different types of noxious agents like traumatic injuries, pain, infection and inflammation, heat or cold. He focused on the endocrinological processes that take place in the organism confronted by a variety of adverse influences and outlined three stages of the adaptation reaction – initial (alarm) reaction, stage of growing resistance and stage of exhaustion. From his point of view these stages to a certain extend resemble the whole life course of the individual – from restless and a little anxious childhood to more stable and steady adulthood, and then to the older age with inevitable lowering of vitality, tiredness and more frequent diseases (Selye, 1937).

The essence of his theory was a non-specific character of GAS, which was confirmed by observations of the uniformity of pathological changes in the animal organism (adrenal glands hypertrophy, thymus and other lymphoid tissues atrophy and intestinal mucosa ulceration) under different adverse influences (Selye, 1937). On the other hand, when trying to extend the theory to humans, he already distinguished between "good and bad stress" – eustress and distress, thus starting a process of diversification of the concept, which initially was so uniformly and logically described (Selye, 1974). Besides, some authors in opposition to the idea of absolute non-specificity of the stress-reaction started to point on differential pituitary-adrenal cortical responses in animals and humans, especially when such factors as pain and psychological stimuli were involved (Mason, 1971). They have argued that, in physiologist's and biochemist's experiments, these factors often seemed to be negligible in the shadow of such drastic physical variables as trauma, heat, cold, fasting, etc. Analysis of Selye's views shows that his theory overlooked or diminished the role of the nature and severity of the stressor, the importance of its perception, as well as extremely important role of higher cognitive functions and individual variability of the psychological processes involved in stress-reactivity (Sukiasyan et al., 2003).

Further studies of the nature of stress have been mostly influenced by two revolutionizing scientific developments (Sapolsky, 2015). The first was associated with understanding that brain, specifically its hypothalamic part, acts as an endocrine gland, secreting releasing and inhibiting hormones into the hypothalamic-pituitary portal system. When corticotropin-releasing hormone (CRH) was isolated, the hypothalamic-pituitary-adrenal (HPA) axis was fully delineated as a functional and structural system. The second breakthrough was due to the active involvement of psychologists in the stress studies, which promoted such concept as psychological stress. Psychologists have been using different wording trying to conceptualize general understanding that higher cognitive functions, emotions, perceptions, and thoughts are important factors influencing the level of stress experienced by an individual – psychological, subjective, mental, psychic stress, etc. With this the link between different mental states and neuroendocrine mechanisms of stress was established and recognized.

Eventually, several structured models and concepts of stress from the psychological perspective have emerged, including those suggested by behaviorism, interactionism and cognitive studies. The most widely accepted model today is a transactional model of stress. This model, which was developed by Richard Lazarus, foresees that an individual's cognitive appraisal of a situation determines whether the situation is perceived as a stressor that consequently evokes a stress response (Lazarus & Folkman, 1984). More precisely, the "primary appraisal" of a situation as irrelevant, challenging, or threatening together with the "secondary appraisal" assessing the individual's perceived coping abilities, i.e., competences to control and manage the situation, result in the individual's interpretation of the situation as stressful or not. A situation is perceived as stressful if interpreted by the individual as challenging or threatening and at the same time exceeding the individual's perceived coping resources. In its turn, stress perception and induced stress responses can largely differ between individuals depending on a variety of modulating trait and state influences (Lazarus & Folkman, 1984).

This understanding of stress promoted conceptualization of the perceived stress - a "global and comprehensive stress construct that is based on the concept that individuals actively interact with their environment, appraising potentially

threatening or challenging events in the light of available coping resources" (Katsarou et al., 2013). Perceived stress arises when perceived requirements and demands to an individual exceed the behavioral and emotional resources of the personality. Stress-reaction actually emerges when the person realizes inability to cope with a problem, to overcome frustration or to avoid its negative consequences due to the lack of an opportunity to control any event, process or state. In a great majority of situations, stress is the result of intuitive and even unconscious feeling (rather than on cognitive processing) that coping is impossible. Emerging fear, anxiety and depressive thoughts may add to the existing level of internal feeling of danger becoming the basis of perceived stress, i.e. feeling and understanding of how much stress we are experiencing. Perceived stress is measured not by the accumulation of stressors (for instance, negative life events), but by summarizing uncontrollability and unpredictability of one's life, one's ability to deal with problems and difficulties. It is based on a general perception of the stressfulness of one' life and ability to cope, and in such form, it is represented in the most popular Perceived Stress Scale (Cohen et al., 1983).

The collateral result of psychological studies was the conceptualization of the stress reactivity – a variable associated with different levels of cognitive, emotional, behavioral, and physiological responses based on personality variables. Recently important data were obtained proving that stress reactivity is a genetically based trait, which is also dependent on the process of early development of the individual, early adverse effects (including in utero) (Brent & Silverstein, 2013). Early adversities also seem to be the main reason of stress-diathesis, i.e. pathologically enhanced reactivity to stressful stimuli (Brent & Silverstein, 2013).

Another dichotomy was associated with differences between acute and chronic stress and comparison between animal world and humans. For instance, R. Sapolsky indicates that the stress in animals is usually short-term event (though potentially deadly, such as an attack of a predator), but the overwhelming part of the life-time of animals is devoted to nutrition, reproduction, and relaxation (Sapolsky, 2015). What is most important is that animals after each stressful situation do not ruminate what would happen if they couldn't escape from a predator and they are never anxious in advance, expecting new misfortunes or being emotionally disturbed about future. The human being in this sense is an example of the opposite – the most part of our time we stay in tension, while periods of relaxation and rehabilitation are getting shorter and shorter. In a more recent historical perspective, since humanity has shifted towards modern types of labor that demands high mental activity, the possibility to escape from overwhelming thoughts and to relax have been reduced substantially. The majority of our negative emotional experiences are associated with reflections how to cope with the freight of duties and responsibilities. Modern humanity is disturbed by anticipated problems and regrets about unused opportunities or about wrong decisions. Of course, the intensity of these negative feelings and perceptions is the subject of great variability due to personality traits, values, abilities of self-regulation and individual predispositions.

Recognition of the contribution of psychological and personality variables and evaluation of the role of internal experiences was an important step in developing the modern concept of stress. The logical continuation of this process was acknowledging and evaluating the role of social factors. This led to a concept of psychosocial stress. This concept is sometimes referred to as work stress or occupational stress, though psychosocial stress is obviously a more general concept, embracing a variety of social determinants. From this point of view such entities as marital stress, academic stress, job stress, as well as life stress, which also appear from time to time in scientific literature, are also looking rather like special cases of the psychosocial stress.

The fact that the concept of psychosocial stress was growing within the framework of occupational medicine is not surprising. Most types of modern stressors in large cities (it should be noted that urbanization is in progress and already more than 50% of people globally live in cities) are usually generated by living and working conditions. It is considered that work stress occurs when there is a combination of high demands (high output requirements and multiple responsibilities) with the inability to influence or control (low task variety and rigid system to control how the work is done) or when feeling of injustice is dominating based on the imbalance between effort spent and reward (Theorell & Karasek, 1996; Siegrist, 1996). In addition in modern society not only high intensity and growing inequality take place, but also a high variability of activity is observed. Fast changes in the markets, mobility of companies, changing tasks and new challenges demand constant adaptation, while the high level of competitiveness and constant tension together with enormous information flow impose additional requirements (Lundberg, 2006). More generally speaking, Western civilization based on liberalism – free access to information, freedom of entrepreneurship, high level of technologies, and especially following the socially approved behavioral models and consumption strategies – generate constant stress associated with competitiveness, inequalities, psychological tension, high pace of life, information overload, responsibility for decisions

made, instability and uncertainty. It gradually turns into a threat to the well-being of the individual. Prolonged psychosocial stress can give rise to a range of problems that are widespread in the modern humanity (often in comparatively young people), like poor performance, chronic fatigue, disinterest, memory and sleep disturbances, diffuse muscle pains, followed by depression, metabolic syndrome or cardiovascular diseases (Danielson et al., 2012).

This again returns us to the comparisons between stress in the animal world and in humans - our body is designed to confront sudden physical threats and to endure protracted physical activity; today, however, we are increasingly exposed to sudden psychological and mental stressors and are captured by chronic hypodynamia. The last is associated with the sedentary lifestyles inevitably imposed by office environment and restricted physical operations, which in association with hectic and mentally taxing work paradoxically lead to constant muscle strain leading to unspecific pain and consequents joints and bone problems (Danielson et al., 2012). In general civilized humanity faces natural biological and physical stressor less and less, while the pressure of psychological factors caused by the work strain, mental fatigue, information overload, hectic work style, interpersonal conflicts and mental stress are becoming increasingly common. It does not mean of course that we cannot experience typical types of stress, like running for our lives to escape a natural disaster or hostile attack. However, a majority of human population, which is currently moving towards 8 billion, experience stress as work overload, loss of control, economic problems, family problems, poverty, unemployment, conflict, and frustrations.

There is a consensus that this "human" stress in which the social component is crucial (work, unemployment, competitiveness, money, society, relations, etc.) is the most common type of stress of modernity. For a human being societies, communities, families, work, relations and higher level life goals like self-realization create the primary context of existence, therefore stress produced by failures, frustrations, break off relations and problems in life are largely dictated by these wide social factors. On the other hand, stress of modern life, being psychosocial by nature, is utilizing quite the same conservative biological mechanisms that are inherent to all mammals (Charmandari et al., 2005). This contradiction, in our opinion, is the main pathological factor of the modernity. It was addressed in many studies, and the most recent development in this field is the conceptualization of the phenomenon of allostasis, which supplements classical understanding of homeostasis, which was in the basement of the initial concept of Hans Selye.

The concept of allostasis appeared to be very relevant for understanding health-damaging effect particularly in case of chronic psychosocial stress when social environment is the main source of stressful experiences (McEwen, 2012). There are many signs that long-term effects of unavoidable and repeated stress lead to “wear and tear” of the biological systems of the organism followed by physiological, emotional, cognitive and behavioral consequences. This “wear and tear” is the results of complex interactions between different parts of the regulatory neuroendocrine system of the body. The essence of a pathological development is that each new steady operating state induced by stressful challenges and demands leads to higher tension in the counterbalancing systems of the organism. As a result in progression of chronic psychosocial stress, balance between systems is achieved on a substantially higher level of their activity. An analogy to this is a see-saw, which is balanced by two heavy weights as compared with the same see-saw balanced with much lower weights. In both cases, the balance is reached, but the energy developed by the weights as well as the strain applied to the fixed support, are very different from one case to another. The strain in the body due to constant ups and downs and huge efforts of regulatory systems to keep the balance is defined by the author of the concept as “allostatic load” (McEwen, 2012). The most serious negative results may follow if one of the counterbalancing systems is compromised or suddenly break.

When speaking about allostatic load, a typical busy workweek is taken. Cyclic type of occupational stress with high demand, low control, and constant pressure is a known risk factor for coronary heart problems and cerebrovascular diseases, associated with atherosclerosis (Kamarck et al., 2004). Actually, working week load is thought to be quite well balanced by week-ends, and it is supported by all human practice. But in fact the problem is deeper; it seems to be imprinted in the biological mechanisms that are confronted by the new type of stress that is inherent to modern life. When one heavy weight is removed from the sew-saw (relief and lowering of stress exposure) organism needs time to adjust for new balance, and in such situations different problems with seemingly unconnected systems may evolve. For instance, it is well known that after a period of serious strain long-awaited resolving of the situation and obvious relief are often followed by an unexpected health problem, like infectious disease or depression. Really, colds and other infections in modern life often manifest themselves on week-ends or on vacations after a prolonged period of intense demand, while depression can become most evident shortly after the holiday, etc. (Kamarck et al., 2004).

These models of stress, especially psychosocial and perceived stress to a great extent explain how "social factors get under the skin". Within this context, the ability to cope with psychosocial stress, in fact, means the ability to restrict biological responses of the body. This ability is not only the result of previous experiences, memories, and strategies one have used to solve problems and to overcome obstacles and problem situations, but also a more a conscious strategy protecting one's physical and mental health, based on the psychology and attitudes to healthy lifestyles. Cortisol peaks are not only stimulated by outcomes of cognitive and emotional transactions, but also contribute both to emotional and cognitive features that may result in stress-vulnerability and stress-resilience based on coping strategies (McVikar et al., 2013). On the other hand as recent studies have proved, stress-vulnerability and stress-resilience are dependent on previous experience and are largely determined by early life conditions, up to puberty and even later (Sapolsky, 2015; King, 2016). This "biological embedding" of the reactivity to stress is largely dependent on epigenetic events which take place during development as a result of stressful experiences, starting from in utero (Herbison et al., 2015). Epigenetic events (molecular modifications of DNA and chromatin, as well as some regulatory RNAs dynamics), which are induced by stress hormones, have been recently identified as a potent mechanism of programming long-lasting changes of the biological systems of stress-reactivity, thus designing them for living in low-stress or high-stress conditions (King, 2016; Herbison et al., 2015; Rozanov, 2017).

Subjective stress as a personal feeling of the pressure of surrounding psychosocial triggers can be differentially perceived by representatives of different cultures, can be influenced by mentality, local traditions and attitudes to diseases and life in general. In a recent study, biological responses to stress were measured in representatives of three big cities – New York, Moscow and Taiwan with regards to sex differences (Glei et al., 2013). Several markers including standard cardiovascular/metabolic risk factors as well as markers of inflammation and neuroendocrine activity were measured. Subjective psychological stress was measured by the perceived stress scale (Cohen et al., 1983). Only Moscow sample demonstrated positive association with overall dysregulation for both sexes. In the US, there was an association for women but not for men. Among the Taiwanese who reported the lowest perceived stress, there was no association for women but an unexpected inverse relationship for men. The association with perceived stress was most consistent for standard cardiovascular/metabolic factors, a little less with inflammation and neuroendocrine activity for some samples. Although the evidence that perceived stress is the primary source of physiological dysregulation is generally modest, it was stronger in Russia where the level of perceived stress was particularly high (Glei et al., 2013). Thus, ethno-cultural component plays an important role possibly moderating biological responses to psychosocial stress. It is also interesting to mention that talking about stress is rather common nowadays; the word "stress" becomes a part of a common discourse, which is also dependent on the cultural context. Talking about stress, claiming high level of stress or complaining about stressful life both help to explain one's own state and, possibly, help to cope with it due to the evoked social support (Pietilä & Rytkönen, 2008). On the other hand, in some cases, it may lead to enhancement of internal feeling of stress if social support is scarce.

This short essay gives an impression how the concept of stress has been the subject of evolution – from general adaptation syndrome considering mostly endocrinological regulation in animals to psychological perceived stress concept, based on deep internal feelings, emotions and cognitions interaction, so characteristic for a human being. On the other hand the initial idea of Selye which was putting forward the uniformity of stress as an internal reaction is still valid and widely recognized. Each type of stress, including one tightly associated with social and personality factors, utilizes the same neuroendocrinological mechanisms of the human body, known today almost in details due to animal studies. Moreover, the concept of stress seems to become a part of a cultural context and is influenced by mentality, attitudes and values. It is quite possible that the concept will be developed further and will be filled with new content.

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