

The Biological Aspects of Physiological Anthropology with Reference to its Five Keywords

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Abstract The methodology of physiological anthropology has been defined in the capacity of an independent academic field by five keywords: *environmental adaptability*, *technological adaptability*, *physiological polymorphism*, *whole-body coordination* and *functional potentiality*, clearly suggesting the direction of approach to human beings in the field of physiological anthropology. Recently, these keywords have attracted a great deal of attention from physiological anthropologists in Japan. Physiological anthropology is based on a biological framework. From the viewpoint of biology, it is essential to discuss the biological function of human behavior. In this brief conceptual manuscript, the biological aspects of physiological anthropology are discussed in relation to the five keywords. *J Physiol Anthropol Appl Human Sci* 24(3): 231–235, 2005 <http://www.jstage.jst.go.jp/browse/jpa> [DOI: 10.2114/jpa.24.231]

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1. Introduction

The highly developed state of our cerebral cortex has enabled us to develop the science and technology that form a vital part of modern society. These types of strategies for our survival and prosperity are special features of humans and are not seen in other species. Clothing, housing and technology are concrete examples of our cultural adaptation. They help protect us from a harsh environment, enable us to set up a stable food supply and have vastly improved the overall quality of human life. However, this artificially created environment has now become a threat not only to man but also to other species. Science and technology, our chosen survival strategies, now require that we make further adaptations (Baker, 1984; Iwanaga et al., 2005). Physiological anthropology calls this type of ability “*technological adaptability*,” a factor that will have a significant impact on the future life environment of human beings.

Technological adaptability concerns a wide area of our artificial environment. Cities, housing, computers, transportation, telecommunications, sophisticated information systems, etc. are indispensable for modern life. In the not so distant future, man may even have to adapt to life in a space station.

Living organisms are at all times exposed to some kind of stress. However, man-made environments contain new stress-inducing elements that were not present in our natural environment in the past. The author believes that the improvement of intellect that accompanies the development of the cerebral cortex is a strategy in human evolution and that this also forces us to adapt to increasing techno-stress (Iwanaga et al., 2005). In this paper, the meaning of the five keywords of physiological anthropology and how they relate to each other, focusing on the biological functions of human behavior, will be discussed in order to show the future directions of physiological anthropology.

2. The Special Nature of Physiological Anthropology as a Natural Science

A goal that physiological anthropology shares with other natural sciences is to explain observed phenomena and build a universal methodology. Physiological anthropology is related to physical anthropology and is based on human biology. Therefore, it must conform to the methodologies of natural science and biology.

The empirical facts of physiological anthropology consist mainly of physiological data obtained from phenomena observed in the laboratory. These empirical data must be accurate, objective and universal in order to contribute to the building of theory. The objective of physiological anthropology is to assemble such empirical evidence to build a methodology as part of human biology. Consequently, empirical facts observed under special circumstances that cannot be generalized and subsumed into the theory would not be helpful in contributing to the scientific structure of physiological anthropology.

However, compared to other areas of the natural sciences

such as physics, chemistry, mathematics, etc., it can be thought that the methodology of physiological anthropology has various different unique facets.

The first differing aspect of physiological anthropology is concerned with the features that relate to biology. Living organisms differ in many different ways. Living organisms, in the process of evolution, have differentiated in many different directions up to the current day. And, within the same species, as individual specimens or in groups, they have come to have widely varying functional, morphological and behavioral characteristics. This type of diversity cannot be observed in other areas of the natural sciences such as physics.

The second different aspect of physiological anthropology is that the objects of study of physiological anthropology are we ourselves, human beings, which have unique physiological functions compared to other animals in nature. In short, this refers to very highly developed mental abilities and it is impossible when studying human beings in a comprehensive way to ignore the existence of these unique abilities. Such abilities as communication based on language and daily life based on technology cannot be found in any other species of living creature. In addition, these highly advanced mental abilities together with the biological value judgment of emotion form the complicated human nature of "*kansei*" and "*pleasantness*". This is the reason why they have become a major theme of investigation for physiological anthropology, although little attention has been paid to them in the arena of natural sciences (Sato, 2000).

In addition, in order to understand the uniquely complicated human nature, it has also been necessary to consider society and culture that are normally not taken up by the natural sciences.

According to the discussion described above, such efforts of physiological anthropology can be seen to be natural and reasonable, because physiological anthropology is an area focused on the understanding of human nature.

This endeavor by physiological anthropology to achieve a greater understanding of human beings is not limited to simply achieving a better understanding of physiological mechanisms and arriving at a better grasp of their functions. Although based on the natural science of biology, physiological anthropology goes beyond the study of physiological mechanisms as such and, within the surrounding matrix of the environment, culture and society, seeks to study how the human species continues to exist and to explore the nature of human existence.

3. Physiological Anthropology and the Methodology of Biology

Physiological anthropology is based on the theoretical structure of biology. Thus, its theoretic structure embodies the biology of the human species. The basic aim of this methodology of biology is the exploration of functions related to the behavior of living creatures. Put another way, it seeks the

answers to the question, "Why does a specific behavior exist?" (Here, the term "behavior" is used in the broad sense of the word and is used to refer to any and all activities of the body that can be observed in an objective way). In other words, the aim of physiological anthropology is to explain human behavior from the viewpoint of physiological mechanisms making it possible to clarify the roles of the related biological functions.

The function of biological behavior consists, in general, of "behavior that contributes to the survival and reproduction of the individual (narrowly defined)" and "behavior that contributes a useful effect for the organism (widely defined)". However, when it comes to human beings living in modern society, there are many cases where it is very difficult to clarify the functions of specific behavior. Thus, where should human behavior-related functions to be studied by physiological anthropology be sought?

One approach, when there is empirical evidence that cannot be explained in terms of such concepts as "behavior that contributes to the survival and reproduction of the individual" and "behavior that contributes a useful effect for the organism", would be to exclude such empirical evidence from an object of physiological anthropology. If this approach is used, on the surface at least, this might be seen as being confining and as narrowing the scope of physiological anthropology. However, for the purpose of building a unique methodology, this approach can be thought to be normal and proper. However, the empirical evidence of physiological anthropology concerns the physiological mechanisms of human beings. Thus, a more reasonable approach would be to take the position that physiological mechanisms indicate a "useful benefit to human beings" originally.

However, there is one more very important problem to be dealt with: A verification of the "useful effect to human beings" is not always found in relatively short periods of time. There are many cases where it is very difficult to conclude what is "useful" and what is "not useful". However, according to biological methodology, the functions of human behavior can be interpreted with reference to such theoretical concepts of biology as "adaptation" and "evolution".

4. The Biological Functions of Human Behavior and the Keywords of Physiological Anthropology

Physiological anthropology is based on the viewpoint of studying human behavior as being based on physiological mechanisms. These biological functions, based on behavioral physiological mechanisms, produce some useful effect for the organisms. Thus, as a result, they are perceived as being a form of "adaptation." When considering the above, it is only natural and quite understandable that such key words of physiological anthropology as "*environmental adaptability*" and "*technological adaptability*" are used.

In order to understand "behavior-based physiological mechanisms" as a biological function, it is necessary to grasp

the various physiological functions as systems that exist at the individual's level. Putting this matter another way, in a case where the various physiological functions are perceived as independent phenomena, the biological function cannot be understood or else there is likely to be a large possibility that a mistaken interpretation and understanding of such phenomena may occur. This is reflected in the meaning of the term, "*whole-body coordination*."

If this "behavior-based physiological mechanism" is thought of in terms of being a biological function that contributes to adaptation and evolution, then it is impossible to ignore the existence of a latent physiological function. Putting this in different terms, these considerations lead to the concept of the change over time of the physiological mechanism as being accompanied by the appearance of a latent physiological function. This leads to the matter of "*functional potentiality*".

In addition, the accomplishment of a biological function of a behavior-based physiological mechanism is a form of adaptation. Thus, it is not possible to ignore the wide variations of these forms of adaptation in relation to environmental factors. In other words, the question of whether the behavior-based physiological function is beneficial depends on its relationships with environmental factors. This is expressed as "*physiological polymorphism*."

As can be seen from the above, the five keywords suggest the methodology of physiological anthropology discussed with regard to biological function, briefly and comprehensively. In other words, these terms have been positioned as main elements of the structure of the theory of human biology that underlies physiological anthropology. The author believes that henceforth, there will be a need to rapidly clarify the entire configuration of the underlying structure of the methodology and to establish guideposts for all individual study projects.

5. The Inter-relationships of the Five Keywords

Concerning the five keywords of physiological anthropology that were explained above, "*physiological polymorphism*," "*whole-body coordination*," "*functional potentiality*," "*environmental adaptability*" and "*technological adaptability*", it is very difficult to explain each of these keywords separately without involving any of the others because they all have close inter-relationships. Especially in the case of "*environmental adaptability*" and "*techno-adaptability*," it is possible to position them as ranking above the other three keywords. These two keywords express an essential characteristic feature of the human species in their long process of evolution up to the present day and can be said to relate to a methodology that underlies all of anthropology.

Taking this meaning into consideration, the author feels that no matter what keyword is considered, it is critical to understand its relationships with the other keywords and its relative positioning.

In the case of *physiological polymorphism*, as a phenotype of human physiological reactions, the term is used to refer to

the existence of many different types of physiological phenotype that exist within a given group. In addition, the human physiological reaction as a phenotype consists of interaction between multiple physiological mechanisms (*whole-body coordination*). And within these multiple physiological mechanisms, some mechanisms are observable and some are not observable. However, in the process of adaptation, the non-observable mechanisms change to become observable and form a new biological function (*functional potentiality*). It is possible to understand that the different content of *whole-body coordination* and *functional potentiality* causes several physiological phenotypes (*physiological polymorphism*). In addition, based on many different environmental factors, the changes in content of *whole-body coordination* and *functional potentiality* can be perceived as physiological mechanisms of *environmental adaptation* that represent useful changes for survival in a given environment. Concerning the term *technological adaptability*, it is used in relation to the general category of *environmental adaptation*, especially in the case of adaptation to man-made environments.

6. Mental Stress and the Keywords of Physiological Anthropology

It can be thought that there are many different approaches to the subject of the *technological adaptability* of human beings. However, the author is interested in physiological reactions to mental stress. In this case, mental stress can be assumed to be techno-stress resulting from the interrelationship between the sophisticated human intellect and the technological support of life. The author and colleagues defined "techno-stress" as not only stress owing to inadequate human-machine interface, but also stress owing to the complexity of daily life systems supported by highly advanced technology (Iwanaga et al., 2004).

As an approach to this type of mental stress, the central nervous system as an entity of mental activity and the following reactions from related peripheral organs could be dealt with. The following is an example of a study of mental stress based mainly on changes in blood pressure and circulatory system indices.

Many studies concerning mental stress have been reported, and as an experimental setting for stress, mental arithmetic tasks and color word tasks, etc. have been used (Cropley et al., 2002; Gregg et al., 1999; Garde et al., 2002; Iwanaga et al., 2000; Kop et al., 2001). It is well known that concerning the physiological reactions to these types of mental stress, there are large differences in results depending on the type of stress used and on individuals (Iwanaga et al., 2000; Lawler et al., 2001; Melis and van Boxtel, 2001).

Ring et al. (2002) found that several different types of physiological reactions to mental arithmetic tasks based on the contribution of the change in cardiac output and total peripheral resistance to increase in blood pressure. According

to their report, there was a rise in blood pressure in response to mental arithmetic tasks that resulted in an increase in cardiac output in one group, and another in total peripheral resistance. The degree to which these factors contributed to increase in blood pressure changed with time allotted to carry out the mental arithmetic tasks. Bongard et al. (2002) found that cardiovascular reactivity to mental arithmetic tasks of second-generation Turkish migrants in Germany was affected by differences in their levels of acculturation to German society. In their report, highly acculturated groups showed larger responses of heart rate, cardiac output and total peripheral resistance than less acculturated groups.

These reports dealt with cardiovascular reaction to mental stress as the coordination of blood pressure, cardiac output, total peripheral resistance and so on. The implications of these studies are significant when examined in terms of the five keywords of physiological anthropology because they tried to clarify the variation of reactivity and the effects of acculturation and genetic factors on it. These reports were almost all designed with the aim of seeking risk factors related to heart disease. However, from the physiological anthropology standpoint of *technological adaptability*, more advances in these types of studies can be anticipated.

Currently, the author and colleagues also use mental subtraction tasks, etc. as an experimental model of techno-stress to examine *technological adaptability* related to *physiological polymorphism* (Iwanaga et al., 2004, 2005). Based on our results, it has been shown that there are several types of cardiovascular reactivity to mental tasks based on the different contribution of changes in cardiac output and total peripheral resistance to rises in blood pressure.

Henceforth, the influence of mental stress on the sympathetic nerves of the heart and the peripheral vessels will be evaluated quantitatively and physiological models of these stress-induced responses including the cardiovascular system are being built from the viewpoint of *whole body coordination*. In addition, we think that there is a need to clarify the role of differences in the duration of exposure to techno-stress and genetic and cultural background effects, etc.

7. What the Five Keywords Indicate

Up until the present time, among studies in the arena of human science, it is thought there have been relatively few studies that have focused on individual differences and the diversity of human beings from the viewpoint of individual biology. Originally, in the area of biology, the existence of polymorphism has been virtually omnipresent and the human species is no exception. The studies of polymorphism among human beings, as represented by successes in the analyses of the human genome, have dominated genetic polymorphism studies.

However, from the standpoint of anthropology that seeks to discover the interplay of the three sources of basic influence on the existence of the human species, environment, genetics and

culture, the elucidation of physiological diversity as phenotype and related mechanisms such as *whole-body coordination* and *functional potentiality* is a matter of great concern. Furthermore, the approach to human adaptability (*environmental adaptability* and *technological adaptability*) based on these mechanisms is probably essential to explore the human nature. The five keywords have not been used in the various other areas of human science. They have remained a special feature of physiological anthropology. The author feels that the use of these terms will cause a re-realization of an intrinsic approach to study human beings.

The methodology of physiological anthropology as a human science is aimed at achieving a better understanding of the nature of human existence. Compared to the other areas of human science, there is an independent quality in physiological anthropology (Iwanaga, 2003, 2004). The methodology of physiological anthropology described in this conceptual manuscript will, the author believes, increasingly become an absolutely essential area of human sciences in the near future.

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References

- Baker PT (1984) The adaptive limits of human populations. *Man* 19: 1–14
- Bongard S, Pogge SF, Arslaner H, Rohrmann S, Hodapp V (2002) Acculturation and cardiovascular reactivity of second-generation Turkish migrants in Germany. *J Psychosomatic Res* 53: 795–803
- Cropley M, Cave Z, Ellis J, Middleton W (2002) Effect of Kava and Valerian on human physiological and psychological responses to mental stress assessed under laboratory conditions. *Phytother Res* 16: 23–27
- Garde AH, Laursen B, Jorgensen AH, Jensen BR (2002) Effects of mental and physical demands on heart rate variability during computer work. *Eur J Appl Physiol* 87: 456–461
- Gregg ME, James JE, Matyas TA, Thorsteinsson EB (1999) Hemodynamic profile of stress-induced anticipation and recovery. *Int J Psychophysiol* 34: 147–162
- Iwanaga K, Saito S, Shimomura Y, Harada H, Katsuura T (2000) The effect of mental loads on muscle tension, blood pressure and blink rate. *J Physiol Anthropol Appl Human Sci* 19: 135–141
- Iwanaga K (2003) *Physiological anthropology with the focus on techno-adaptability*. *Jap J Physiol Anthropol* 8 (Suppl 2): 20–21 [In Japanese]
- Iwanaga K (2004) *Physiological anthropology with reference to its keywords*. *Jap J Physiol Anthropol* 9 (Suppl 2): 14–15 [In Japanese]
- Iwanaga K, Liu X, Shimomura Y, Katsuura T (2004) Human adaptability to city life supported by highly advanced

- technology. Abstract book of 7th ICPA: 18–19
- Iwanaga K, Liu X, Shimomura Y, Katsuura T (2005) Approach to human adaptability to stresses of city life. *J Physiol Anthropol Appl Human Sci* 24: (in press)
- Kop WJ, Krantz DS, Howell RH, Ferguson MA, Papademetriou V, Lu D, Popma JJ, Quigley JF, Vernalis M, Gottdiener JS (2001) Effects of mental stress on coronary epicardial vasomotion and flow velocity in coronary artery disease: relationship with hemodynamic stress responses. *J Am College Cardiol* 37: 1359–1366
- Lawler KA, Kline KA, Adlin RA, Wilcox ZC, Craig FW, Krishnamoorthy JS (2001) Psychophysiological correlates of individual differences in patterns of hemodynamic reactivity. *Int J Psychophysiol* 40: 93–107
- Melis C, van Boxtel A (2001) Differences in autonomic physiological responses between good and poor inductive reasoners. *Biol Psychol* 58: 121–146
- Ring C, Burns VE, Carroll D (2002) Shifting hemodynamics of blood pressure control during prolonged mental stress. *Psychophysiol* 39: 585–590
- Sato M (2000) Invitation to reality and perception: Physiology within the framework of anthropology. *Proc 5th ICPA*: 293–294
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