A Tentative Proposal on Physiological Polymorphism and Its Experimental Approaches

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Abstract The purpose of this paper is to propose a tentative concept of physiological polymorphism and experimental approaches to it. We think that the concept of physiological polymorphism is to categorize the diversified phenomena into various types with statistical methods and to explain the differences among the categorized types from the viewpoint of their physiological mechanisms. Furthermore, it is necessary to take into consideration the fact that physiological polymorphism is observed as a phenotype, and the phenotype results from a genotype modified by culture and environment. As an experimental approach, we studied the effects of gustatory stimulation by chocolate on the activities of the prefrontal area and found that the activities were increased in some cases and decreased in other cases. Therefore, to begin with, when we divided them into an “increasing group” and a “decreasing group,” we found that the increasing group had many subjects of Type B and High anxiety, and the decreasing group had many subjects of Type A and Normal anxiety. By the chi-square test for independence, it was found that the ratio of “increase” and “decrease” was related to the trait anxiety and type A personality, respectively. Next, we divided the activities of the prefrontal area into Type A and Type B, as well as a high anxiety group and a low anxiety group. As a result, the Type B and high anxiety groups showed significantly increased activities, while the Type A and normal anxiety groups showed no changes in their activities. Consequently, this data enabled us to explain the difference in activities of the prefrontal area from the viewpoint of personality characteristics. To conclude, we were able to categorize diversified changes in the prefrontal area into certain types when a gustatory stimulus was applied, and to explain them by using personality characteristics (State Trait Anxiety Inventory, Type A behavioral pattern) that are commonly known for their reflection of genotypes. J Physiol Anthropol Appl Human Sci 24(4): 297–300, 2005 http://www.jstage.jst.go.jp/browse/jpa [DOI: 10.2114/jpa.24.297]

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The population of the same species shows the diversified conditions and changes in various physiological functions. We think that the concept of physiological polymorphism is to categorize the diversified phenomena into some types with a statistical method and to explain the difference of the categorized types from the viewpoint of their physiological mechanism, genotype, culture and environment. The explanation of the different types requires measuring the absolute values of multiple physiological indexes, which enables us to examine the physiological mechanism. Also, we need to take into consideration the fact that physiological polymorphism is observed as a phenotype and the phenotype results from a genotype modified by culture and environment.

Meanwhile, there is a word, “systemic coordination,” contained in the keywords of physiological anthropology. We assume that it means that the coordination of the body’s various organs makes the functions of the whole body harmonize well with each other. When we find a different type in a physiological function and explain how different the type is, it is important to consider human physiological conditions systematically using multiple indexes, such as central nervous activities, autonomic nervous activities, endocrine activities, and immune activities, which require a viewpoint of systemic coordination.

Now we look at the relation with “individual differences,” which is attracting interest in various fields. The major problems with the study of physiological “individual difference” which have always been questioned are as follows: 1) It observes various phenomena targeting just individuals instead of populations; 2) A single measurement index has been used in many cases. While on the other hand, the study of physiological polymorphism 1) deals with human beings as a population instead of individuals; 2) utilizes a statistical method to categorize different types; 3) measures the absolute values of multiple physiological indexes from the viewpoint of systemic coordination, and explains the different types from the aspect of the difference of their physiological mechanism;
4) deepens its consideration with the factors such as genotype, culture, and environment in mind.

In a gustatory stimulus experiment, we are attempting to observe diversified changes in the brain activities centering on the prefrontal area and explain them with personality characteristics (Tsunetsugu et al., 2003; Tsunetsugu et al., 2004) in the light of genotype. We would like to introduce the attempt, although it may not be a sufficient example, because we are still working on the analysis of the interactions with autonomic nervous activities.

We studied the effects of gustatory stimulation by chocolate on the activities of the prefrontal area and found that the activities were increased in some cases and lowered in other cases with the diverse changes as shown by Figure 1. The experiment was conducted in 17 males (aged 24.1\(\pm\)2.6) in an artificial climate chamber conditioned at about 24°C, 50% relative humidity, and illuminance 50 lx. After we confirmed the resting state of the subjects with their eyes closed in a sitting posture for more than 20 seconds, we ordered them to stick out their tongues, put 0.2 g of milk chocolate in the center of their tongues with tweezers, and ordered them to close their mouths. After 20 seconds, we ordered them to swallow it and to evaluate the taste after 90 seconds. We measured the brain hemodynamics per second in both frontal regions with near infrared spectroscopy during this time. It is thought that this measurement mainly reflects the activities of the prefrontal area (Villringer et al., 1997; Hoshi and Tamura, 1993).

Meanwhile, R. Plomin (Plomin, 1990), in his study of twins, has found that among various personality characteristics, a
tensed reaction (neurotic tendency), social authority (an authoritarian character which wants to attract others’ attention), and aggressiveness are significantly influenced by heredity (Tellegen et al., 1988). Therefore, we attempted to explain the diversified changes in the reaction from the viewpoint of genotype by using STAI (State Trait Anxiety Inventory; Nakazato and Mizuguchi, 1982) as a personality test that reflects tensed reaction and Type A behavioral pattern (Brief questionnaire for detection of type A tendency; Maeda, 1985) as a personality test that reflects social authority and aggressiveness.

The subjects in each test were categorized as follows. In STAI, the subjects with STAI scores of 33 - 43 were classified in the category of “Normal group” (11 subjects) and those with scores over 44 were in the category of “High anxiety group” (6 subjects). (There were no subjects with scores under 32.) In the Brief questionnaire for detection of type A tendency, the subjects with scores over 17 were classified in the category of “Type A group” (8 subjects) and those with scores under 16 were in “Type B group” (9 subjects).

First, when we divided them into “Increasing group” and “Decreasing group” from the aspect of the activities of the prefrontal area, we found that the increasing group had many subjects of Type B and High anxiety, and the decreasing group had many subjects of Type A and Normal anxiety. By the chi-square test for independence, it was found that the ratio of “increase” and “decrease” was related to the trait anxiety and type A personality, respectively.

Next, we divided the activities of the prefrontal area

Fig. 1 Various changes in blood flow in the prefrontal area by a stimulation of chocolate. The activity of the prefrontal area increases in numerical order.
stimulated by milk chocolate into Type A and Type B, as well as High anxiety group and Low anxiety group, for analysis. As shown by Fig. 2, the High anxiety (top of Fig. 2) and Type B groups (bottom of Fig. 2) showed significantly increased activities, while the Normal anxiety (top of Fig. 2) and Type A groups (bottom of Fig. 2) showed no changes in their activities. Consequently, this data enabled us to explain the difference in activities of the prefrontal area from the viewpoint of personality characteristics.

Furthermore, Fig. 3, which shows the results of each subject’s prefrontal area activities, demonstrated that the increasing group consisted of subjects in the Type B or High anxiety groups and that the decreasing group consisted of those in the Type A or Normal anxiety groups.

To conclude, we were able to categorize diversified changes in the prefrontal area into certain types when gustatory stimulus was applied, and to explain them by using the personality characteristics (STAI, Type A behavioral pattern) which are commonly known for their reflection of genotypes. From now on, we would like to explain the differences in the physiological types from the aspect of systemic coordination using the physiological mechanism.

In addition, a method called TRS (Time-Resolved Spectroscopy) (Oda et al., 1996; Quaresima et al., 2005), which has been developed and improved rapidly during the past one or two years for measuring the absolute values of brain activities, is expected to shed light on physiological polymorphism. Its principle and examples of experiments are reported by Dr. Tsunetsugu in this special issue.

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References

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