DISCUSSANT RESPONSE

by

Ryuji Takaki
Professor of Physics
Tokyo University of Agriculture and Technology
Tokyo, JAPAN

to **Vilmos Csányi's**

MIND AND COGNITION: LIMITS OF UNDERSTANDING

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Comments on the paper to be presented at ICUS, Seoul 1991

Ryuji TAKAKI

Tokyo University of Agriculture and Technology

Fuchu, Tokyo 183, Japan

This article includes comments on the following paper to be presented in the committee 1 "The Limits of Science":

Vilmos Csanyi: Mind and Cognition: Limits of Understanding

A summary of this paper is given first, and then my own comments follow.

This author discusses on several concepts concerned with mind and cognition by human beings and animals also. The definitions given to these concepts are mainly of the psychology, especially based on the neuron network in the brain.

He refers to the "cognitive map", which was proposed first to explain the learning process of animals, and is defined as a representation of a real world in the brain.

This internal representation is more precisely explained as a "model" of real world, i.e. a simpler system with a finite number of components. And, "cognition" is considered as "an ability to construct model". This model is interpreted also in terms of neuron system.

The function of the model is discussed in terms of a "key" (connection between the inner and outer world), "action" (neural structure organizing action) and the "referential structure" (functional element linking percept and action). Animal concept is explained by this "key - reference structure - action" unit.

In the human cognitive map the role of language is important, and "word - referential structure - action" unit gives the "conceptual thought". A higher structures of individual concepts are "ideas". An idea is constructed through the "self-organization" from concepts. "Culture" is a social cognitive map, i.e. a social model, which is formed in particular group of people. Furthermore, "mind" is a conceptual thought independent of experience.

"Understanding" is is a connection between two minds or a relation between a mind and a reality. However, the final form of understanding is a connection of neurons. From this fact two types of "limit of understanding" come out.

When we consider the neuron interactions, there are several levels of modelling, i.e. organizational levels. The modelling based on molecules is an upper level of organizational levels. More macroscopic model is at the next higher level. "A limit of understanding" is caused by the lack of relations of a certain level of understanding to both higher and lower levels. "The second limit of understanding" is caused by a finite number of neurons.

I am not a specialist of psychology, and can not discuss on the content of this paper at the same level with this author. But, the purpose of the present conference seems to lie at a different place, that is, to discuss on a topic by people of a variety of fields. Therefore, I give comments from another point of view.

The assertion that understanding something is connecting minds or reality is agreeable. Now, in my field of physics the connection between theory and experiment is believed essential for understanding a physical

phenomena. However, this work amounts to an understanding at a very high level. Until it is obtained, several processes of understandings are taken place at various levels.

In the experimental studies not the true reality but a well controlled reality is the object of investigation. Therefore, the object itself is a "model" of the reality. Each row data obtained in the experiment is, therefore, reflects properties of a system which is near to but different from the reality. Then it is compared with the experimenter's expectation (a mind), and if it is satisfactory it is registered as an understood fact (a new mind). This fact is connected with other facts (other minds) to a more general fact (a mind). By piling up this process we get a universal experimental fact. This is a high level of understanding.

On the other hand, the theory must be mathematically exact, and we must begin with assumptions for treating a real phenomenon mathematically. The process of assumption is to simplify a real phenomenon and to give a mathematical expression to each assumption. This object of investigation associated with enough number of assumptions is a "model", as is often called in theoretical studies. To make up a model is already a kind of "understanding", because a connection between an image of phenomenon in theorist's mind and mathematics has been made. Then, the model is treated mathematically and results are derived. These results are compared with expectation. If it is satisfactory, a high level of understanding is formed.

Both understandings from experiment and theory are compared and the degree of agreement is examined. If they agree, both results are confirmed more strongly than they otherwise have been. This final stage allows the

highest level of understanding. Therefore, in physical sciences the process of understanding is composed of a hierarchical structure.

Recently, the third counterpart has been established, i.e. the numerical computation. It used to be looked upon as a part of theoretical works, but the essential nature of computation is different from theory. Characteristics of the three activities are listed in the following table.

Table 1. Characteristics of three activities.

	difference from reality	advantage	disadvantage
theory	assumptions	exact, no numerical error	mathematical difficulty
experiment	controlled conditions	near to reality	results depend on techniques
computation	controlled conditions	solved for any condition	results depend on techniques

In the fields of physical sciences a true understanding will be obtained after these three results agree each other. We should note here that none of these activities are treating a true reality but a model similar to it.

Why should we take such a complicated process? Two reasons are considered, one is to avoid misunderstanding and another is to make others convinced with the results. A well known example of misunderstanding in the hydrodynamics is introduced below.

At the downstream side of a circular cylinder placed in a uniform flow, a street of vortices, called "Karman vortex" is formed, as is seen from the

visualization picture in Fig.1. The dye streak is injected from the cylinder surface and convected downstream by the flow, while it is rolled up owing to the vortical motion. This deformed streak is a sign of vortices in the fluid.

Now, Fig. 1 gives us an impression that equivalent vortices are arranged periodically, and clear vortical structures exist even at far downstream. Within the visualization study there is no reason to doubt it. But, it is not correct! A measurement of velocity distribution reveals that the sharp vortical structure exists only adjacent to the cylinder, and it has decayed in the far downstream region. The rolled-up streaks had been formed near the cylinder and merely convected periodically to the downstream region. Therefore, the dye pattern does not necessarily indicate vortical motion at the instant of observation.

On the other hand, a theoretical study of this flow based on an inviscid fluid assumption gave a necessary value for the ratio h/a=0.28 (see Fig.2). Agreement of this value with visualization experiment allowed an establishment of the illusion of the long periodic vortex structure. However, if the effect of viscosity is considered properly, the idea of decaying vortex structure will be understood. It is recognized only recently that the dye pattern of Karman vortex are misleading.

I would like to propose another problem coming from my own interest, which is not raised by this author but is considered to be related. Recently, studies of patterns or forms has become popular, especially in the fields of physics, biology, medicine, information sciences and engineering, etc. I am engaged in managing a society "The Society for Science on Form, Japan". The purpose of this society is to promote researches concerned with

patterns or forms. We have now three routes to a final understanding of forms, investigations of properties of the space, mechanism of pattern formation, techniques of morphometry, as is shown in Fig.3.

At present, however, interests of the members are rather scattered and the routes in Fig.3 are taken by scientists of different fields. Namely, it is often difficult to make cooperation or discussion on the common base of methodology and interest.

Now, my present concern is a question what it means to understand a pattern or a form. I have a hope that an answer to this question will serve to unify the interests of scientists. In the past history of physical sciences deeper understandings of phenomena have been accomplished through quantitative descriptions. Then, in order to understand patterns, should we express patterns quantitatively ? If so, how ? A quantitative description is to replace a phenomenon with a group of numbers. Then, if a pattern is replaced by numbers, does it give us a better understanding ? We can recognize spatial structures easily owing to the highly efficient ability of human eyes in pattern recognition. If they are replaced by numbers, they will become harder to understand. Then, again a question: what is to understand patterns ?

On the other hand, sciences concerned with forms or patterns are considered promising in near future, because electronic tools to treat them are being developed very rapidly. However, if we try to promote such a activity, we are always troubled by a question: what should we do with patterns. There is yet no unified concept or method to describe forms, nor is it clear whether understanding patterns is similar to that proposed by this author (V. Csanyi).

Such a question is considered to appear always in pioneering fields. And, the discussions on the limits of understanding will be more needed in such fields.

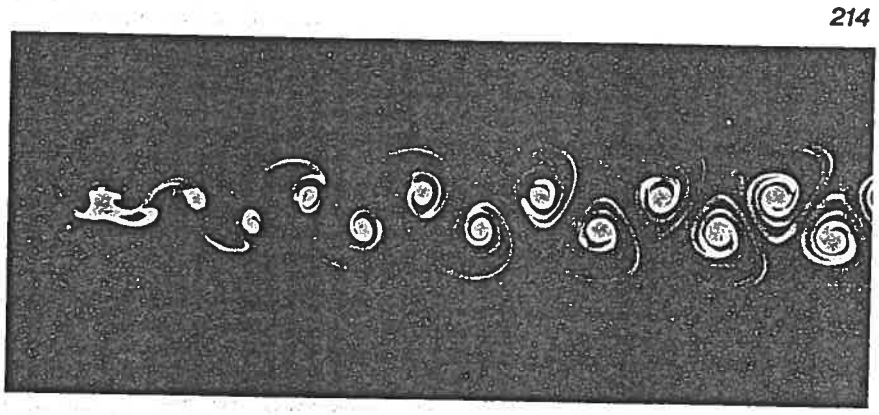
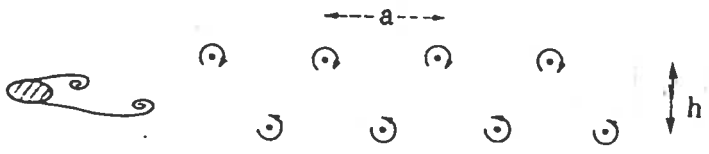


Fig. 1. Visualization of Karman vortex (from T. Taneda; 1988).



Fg.2. Theoretical treatment of Karman vortex based on assumptions of point vortices and a fluid without viscosity.

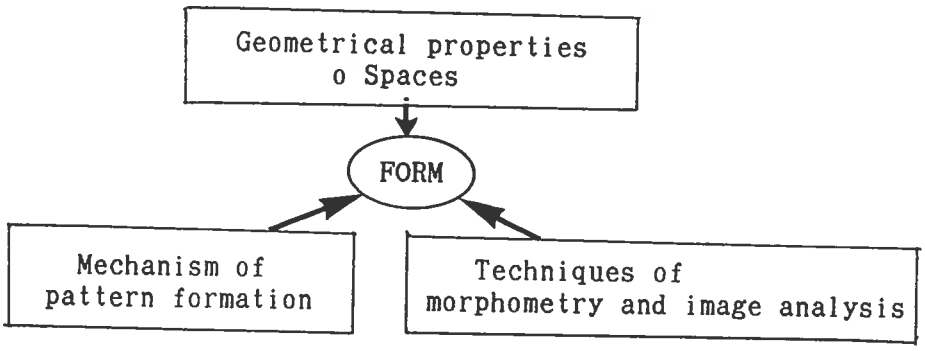


Fig.3. Three routes to an understanding of forms.