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EVOLUTION OF AFFECTIVE EVALUATION OF EXTERNAL STIMULI

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Abstract

Starting from an experimental study on the affective evaluation of sweetness in human subjects an attempt is made to analyze affectivity in the evolutionary perspective. Evolution is viewed as a constructive process creating cognitive systems with steadily increasing multi-level hierarchies capable of ever-increasing derandomization and algorithmization of environment. Affective evaluation is being considered as a relatively late evolutionary innovation differing from purely sensory evaluation of stimuli. Representing a higher-order information processing with considerable abstraction from specific features of stimuli the affective evaluation may not always be compatible with homeostasis of organism and retain adaptive quality. It makes organisms active and conditionable is "need-free" states, emotions themselves becoming autonomous drives and a substratum of reinforcement. Affectivity may have been an important shaping factor in late phases of the biological evolution and may have a major role in the human cultural evolution controlling the formation of human values and ideas.

Introduction

Is the biology of emotions possible? The study of emotions has been an exclusive domain of psychology and one of its most controversial subjects. With respect to their participation in motivation processes emotions have been thought to be either inherent, or concominant, occasional, or irrelevant (for review see Madsen 1968 and Bindra and Steward 1968). The assumption that emotions have an adaptive value is intrinsic to the hedonic theory while emotions have been considered as interfering and disorganizing purposive behaviour by some other theories. Emotions have been treated as causes of behaviour by some psychologists, but also as consequences of behaviour by others.

Such controversies may partly arise from semantic discrepancies. To avoid confusion, affective, emotional and hedonic valuations will be used as synonyma in this paper. A major reason of the existence of so many theories of emotions may have been a tendency for monocausal explanation, specific for each particular theory, of psychological and behavioural processes which is not compatible with considering them a part of a complex, hierarchically organized dynamic system.

The starting point of the account presented here has been a study on affective evaluation of sweetness in humans. It had been thought that such a study might provide a simple model for analysis of affective evaluation of stimuli and of adaptive role of affectivity in general. The results were published in detail previously (Kováč and Varečka 1978). The study was based on the following consideration: It appears reasonable to suppose that man labels with positive hedonic quality, that is, characterizes as pleasant, those external stimuli which are associated with objects or actions beneficial to the human organism. Sweetness of a sucrose solution is generally characterized as pleasant and, indeed, sucrose can satisfy the need for energy in a hungry person. If an organism is satiated, or even overloaded with sugar, so that as additional intake of sugar would not be useful but may even be deleterious will sweetness no longer be labelled as pleasant but rather as unpleasant? Such an assumption is implicit in the concept of alliestesia (Cabanac 1971) according to which the hedonic evaluation serves a physiological role in maintaining homeostasis.

In our experiments (Kováč and Varečka 1978), the affective evaluation of sweetness was not changed after the organisms of experimental subjects was overloaded with sugar by injecting them intraveneously with 100 ml 40% glucose. Thus, there was no correlation between the hedonic rating and the actual need or lack of need of the substance endowed with hedonic potential. Another experiment has suggested that cognitive factors may have taken part in the affective evaluation. Cognitive components cannot be easily differentiated from affective components in experiments with human subjects.

Implications from the Physiology of Emotions

Affective evaluation cannot be treated as nothing but an automatic specific ingredient of processing any sensory information in conscious organism. Sensory and hedonic qualities of a perception appear to be independent (Young 1959). Even in case of pain sensoric and affective aspects can be partly divorced (Melsack 1971). Sweetness and pleasantness have also been found to be ruled by different psychological laws (Moskovitz et al. 1974). Neither would it be justified to consider affective evaluations as conscious "epiphenomena" specific to man. As Darwin already noticed bodily expressions are similar in man and animals and physiological changes that accompany states of feeling are not unique to man but present in all higher animals (Hokanson 1969).

Also common to both man and higher animals is the existence of "rewarding" and "aversive" areas of the brain. A possibility exists that all behaviour is organized in such a manner that the organism aims at receiving a maximum stimulation of the brain "rewarding" areas and at avoiding stimulation of the "aversive" areas. In the natural situation the organism would achieve these stimulations by purposefully interacting with his environment, continually receiving rewarding and aversive stimuli. Artificial stimulation with implanted electrodes in a laboratory setting would represent a kind of "short-circuiting". If "reward" areas were identical with "pleasure centers" and "aversive" areas with "pain centers" behaviour would be adequately described by the hedonic theory. In some investigations, human subjects undergoing stimulation of specific brain areas with implanted electrodes did indeed report pleasant feelings (Delgado 1969) while in other similar investigations they could not report clear-cut sensations (Sem-Jacobsen and Torkildsen 1960). In a most competent review on "emotional centers in the brain" (Olds 1971) Olds maintained that people who performed self-stimulation with implanted electrodes were not aware of their feelings because they confabulated the reasons of this activity. According to his opinion the electric stimulation of "rewarding" areas may have "a general influence causing facilitation or repetition of ongoing behaviour without too much regard for its justification in terms of positive or negative motivational goals".

It seems reasonable to conclude from these observations that "rewarding" and "aversive" areas of brain may represent anatomical and physiological basis for innate drives and for positive and negative reinforcements but cannot be designated as exclusive "sites" of positive or negative emotions. A partial overlap, both phenomehological and anatomical, but not identity would characterize the relation between motivation and emotions. At the evolutionary scale, motivation and emotions should be separable from each other.

A Theory of Evolution of Affective Evaluation

At its basic level life can be viewed as coexistence of various replicators and their competition for survival. Survival of a replicator depends on the rate of its replication and on its ability to evade destruction by environment. Since any replicator represents a non-random sequence of chemical groups or species the latter faculty implies the knowledge of features of the environment, that is recognition of their non-random character by processes subserving the replication. In this sense, biological evolution is, from its very beginning, the evolution of cognition and organisms are congitive structures (see also Lorenz 1973 and Goodwin 1976).

As continual replication is only possible in an open system, the very first replicators must have already resided in elementary protocells. In such a protocell the most elementary "recognition" of environment was represented by restrictions imposed upon the components of the environment by permeability properties of the primitive, presumably lipid, cell membrane.

An additional de-randomization of environment was achieved by evolutionary acquisition of transport proteins located in the cell membrane. A transport protein selectively delivering into the cell a substance advantageous for survival - such as a protein transporting sugar - is a successful result of an "evolutionary theorizing" made by the evolving species on the trial-and-error basis. Each individual of the primitive species carrying a differing protein variant could be considered a representative of a specific theory. The final product of selection, the adequate transport protein, represents the theory of the environment that has passed the test and has not been falsified.

The sugar transport protein could give rise in evolution - upon duplication of the corresponding gene and accumulation of independent mutations - to a membrane protein that is no longer involved in sugar transport but serves as a receptor, a sensor for the particular sugar. In chemotactic bacteria a signal coming from the sensor upon its recognition of the sugar molecules serves to activate an effector in the basis of the flagellum so that the bacterium can purposefully move up the sugar gradient. In more complicated organisms data from several sensors are being pooled, making a more elaborate theory of the environment, and their summation decides on the action of effectors. It is at this level that the nervous system has emerged in the evolutionary process.

Theories of environment elaborated in evolution and corresponding ready-made receptor-effector connections would not satisfy optimal survival of higher species exposed to varied and unpredictable situations of their complex environment. Therefore, learning has come to the stage, enabling second-order programming during the individual life course. However, this second-order programming is governed by the basic programme set up in the volution of the species. It is this basic genomic programme which decides which theory elaborated during the individual life should be disproved as wrong and which theory, and corresponding behaviour, is adaptive. "Aversive" and "rewarding" centers of the brain, preprogrammed in the genome, and corresponding to drives, respectively terminate and protract the ongoing behaviour.

In still higher organisms it may have become advantageous to pool data from different sensors into two distinct sets according to phylogenetically proved advantage or disadvantage for the organism. It is here where affective evaluation by hedonic criteria has emerged. The sensory information "sweetness" from a sugar receptor is receiving the hedonic connotation "pleasant". This would link this information with other physically or chemically unrelated informations, coming from different sensors, which are also labelled as "pleasant" and greatly increase the "theorizing ability" and the behavioural repertory of the animal. The device for the affective evaluation may have evolved in a close connection or concomitantly with the non-specific activation system of the brain which also participates in adequate tuning of the organism to incoming stimuli from the environment.

The evolutionary argument may be supported by the opinion of contemporary students of human infant behaviour who maintain that in the infant there appear to be only two emotional states: the state of excitement which appears to the observer to be emotionally unpleasant one and the state of quiescence which appears to be emotionally neutral (Hilgard and Atkinson 1967). The affective evaluation develops in ontogeny successively as it may have developed in phylogeny.

The hierarchy of theorizing and programming devices attains its peak in man in which a large part of testing environment does not proceed as motor acts but purely symbolic activity. Capacity for an affective evaluation also attains its peak representing, along with abstract thinking, another form of high abstraction and algorithmization of reality. Higher-order affective evaluation can itself be learned on the basis of the elementary affective evaluation and with assistance of the "rewarding" and "aversive" centers of the brain. Results of congitive analysis also receive affective connotations. On the other hand, goal-directness of human thinking may be more secured by our basic affective constant elaborated in evolution than by pure logic.

Representing a high degree of abstraction the affective evaluation could not escape inaccuracy with respect to biological significance. Taste receptors do record sweetness not only of biologically useful sugars but also of inert or even deleterious substances if they have chemical structure which would fit the structure of the receptors. Also, affective evaluation with a satisfactory fittness in conditions under which it had been selected in evolution may turn unfit in novel conditions. Pure sugar may have been a relatively rare food in those time when internal factors controlling hedonic evaluation for sweetness and their feedback were shaped in human evolution. In our days the controlling factors are not strong enough to oppose the easy availability of sugar and its everconsumption has become a serious health problem.

Affective evaluation does not only assist in shaping purposive behaviour directed by innate drives but the search for pleasantness has itself become an independent drive. It has been shown experimentally that higher animals in "need-free" states do exhibit gustative and other preferences (Young 1973). Taking into account the inaccuracy in the relation between affective evaluation and the actual biological usefulness it is clear that just in such relaxed undeprived states conditionning for behaviour which may be non-adaptive or, in a situation of need, even counter--adaptive, would take place. Through the affective relation to environment life appears to transcendent its basic "utalitarian" self-presevation meaning and achieves new dimensions.

The Role of Emotions in Evolution

If products of evolution exhibit increasing hierarchy levels the evolution itself is a hierarchical process. It is appropriate to speak of the evolution of evolution (Wolsky and Wolsky 1976). Once behaviour has appeared as a product of the biological evolution it has become a new factor determining the subsequent evolution: a behaving organism is not only selected by its environment, it selects its environment and modifies it. Likewise, emotions, a still later evolutionary innovation, may have been a formative factor in the evolution of higher animals. They may also have been a causative component of sexual selection the explanation of which in purely adaptive terms meets with considerable difficulties.

There is no transgression to apply notions from psychology to biology once the evolutionary origin of psychological phenomena is admitted. It may be particularly important to attempt such an application to the problem of the evolution of aggression and altruism. A purely biological concept of inclusive fittness may well account for the altruistic behaviour observed in lower animals but reciprocal altruism may have been more important in the evolution of altruistic behaviour in mammals. The concept of reciprocal altruism (Trivers 1971) may have been the first one having a tint of psychological reasoning.

Darlington (1975) has been more explicit considering altruism as a product of "evolutionary reinforcement": altruistic acts may have evolved because evolution made them pleasurable. According to him, satisfactions and rewards may not be directly advantageous but may increase the force of selection of the advantageous behaviour.

In arguing along this line it appears legitimate to use the purely psychological notions of envy and empathy in attempts to explain the final evolutionary shaping of aggressive and altruistic traits in primates, including man. In addition, considering the human cultural evolution as a continuation of the biological evolution by mechanisms of non-genic inheritance it may be pertinent to express the need for a careful study of the major role which the affective components play in the formation of human values and ideas.

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