THE NEUROPHYSIOLOGICAL BASIS OF PLEASURE

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Summary

Description of psychophysiological phenomena was and still is extremely difficult. There is a gap between neurophysiological and psychological description of the same phenomenon. Since the early 1980s there has been a revolution in neurophysiological explanations of several psychological phenomena. This has been based on the discovery and use of imaging techniques like CT (computer tomography), MRI (magnetic resonance imaging) and its functional modification (fMRI), PET (positron emission tomography), Doppler and others. These techniques enable visualization of the different brain structures during various psychological states. In this article we try to describe these effects and to find the neurophysiological explanation for such appearances as love, alcoholism, drug abuse, pain, sexual and passion behavior. Also we try to describe the basic explanation of the needs for pleasure based on Cloninger's typology. We are also able to localize the pleasure in the centers of pleasure and the neuroanatomy of the reward cascade. The molecular basis of the reward deficiency syndrome is mainly

dopaminergic. From this knowledge it is possible to propose treatment of these phenomena.

1. Introduction

How to fulfill the needs for pleasure has been studied through the whole history of humankind. It is characterized by the dilemma between our imagination and the fulfillments of our needs. Many ideologies during the history of humanity tried to fulfill the needs of man in a very broad sense of the word. One of the ideologies of the twentieth century—the socialist ideology—used the slogan: to everybody according to his work. The ideology of communism was: the needs will be fulfilled for everybody up to his needs. It was real utopia. It was no solution for fulfilling it, and therefore it was never reached. Nevertheless, each human being has a tendency to fulfill her/his needs. We may find an answer to the question if we have the biological backgrounds for it. There is also a huge psychological extension of the biological background.

2. Needs for pleasure

2.1. Centers for Pleasure

We know that our emotional system is mainly realized in the limbic system.

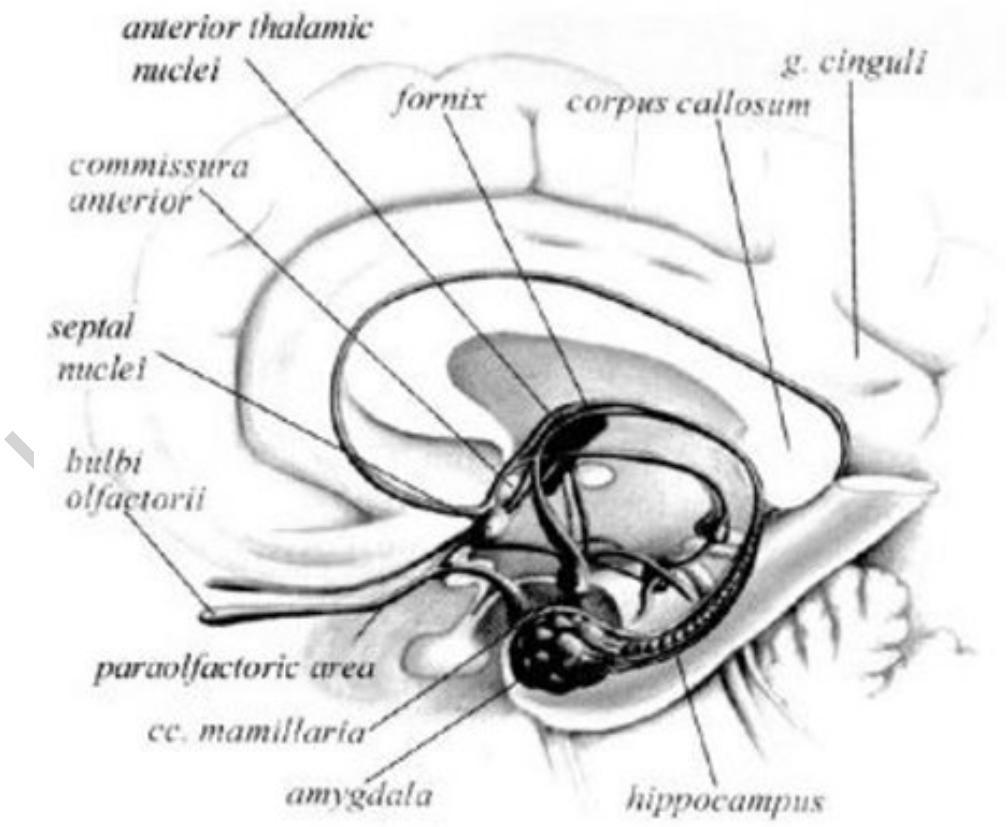

Figure 1. The parts of human limbic system

It has two parts: cortical and subcortical. The cortical one is composed mainly of the rhinencephalon (i.e. cortical representation of the olfactory system). The subcortical part includes the hippocampus (which is very important for memory), amygdala and hypothalamus.

The first discovery of behavior dependent on the center of pleasure was described in 1954 by James Olds, the American psychologists who used an electrical stimulation of certain parts of limbic system. Rats chose to continuously push a lever (press bar) for electrical stimulation of the limbic system (5000 times per hour), and the animals excluded all other activities (like pain and hunger) except for sleep. They also accepted some pain if they were rewarded by the stimulation of this center of pleasure. It was also discovered that stimulation of the medial hypothalamus has a similar effect on the orgasmic feeling in different animals. It is possible to declare that pleasure is an independent biological function, which is very close to the system of reinforcement and reward.

2.2. Neuroanatomy of the Reward Cascade

The reward cascade is started by activation of the mesolimbic dopamine pathway, which starts in the ventral tegmental area and ends in the dopamine D2 receptors on the cell membranes of neurons located in nucleus accumbens and the hippocampus. This was first proposed by Blum et al. (1976). They proved that the process starts in the hypothalamus with excitatory activity of serotonin releasing neurons. This causes the release of the opioid peptide met-enkephalin in the ventral tegmental area, which inhibits the activity of neurons that release the inhibitory neurotransmitter GABA.

The disinhibition of dopamine containing neurons in the ventral tegmental area allows them to release dopamine in the nucleus accumbens and via amygdala in certain parts of the hippocampus. This completes the cascade and the development of reward sensation. The feeling of well-being includes the states of eating and drinking satiety and temperature comfort. When animals are bred in zoological gardens, the new requirements include sexual satisfaction and affective reciprocity as well as the acceptance of family or community groups.

These are general characteristics for mammals, but primates and humans in particular require still more social recognition and economic stability. If this state of well-being is not easily reached, it is necessary to initiate a search for alternatives which may cause the liberation of dopamine to the limbic system. Unfortunately this effect is transitory. If there is insufficient amount of these rewards, then the reward deficiency syndrome begins.

2.3. Cloninger's Typology

According to the theory of Cloninger (C.R. Cloninger, Professor of Psychiatry and Genetics at Washington University, Saint Louis, Missouri, USA) we have a three dimensional typology, with three main characteristics of personality. The first is novelty seeking, the second is harm avoidance, and the third is reward dependence. From these

types, we can distinguish the different types of human behavior. It is, however, difficult to locate each individual person within this continuum.

3. Reward Deficiency Syndrome

Each wild living animal has well developed reactions to safety, warmth and a full stomach. If the needs are not completely and immediately fulfilled, it feels discomfort and anxiety. Similar discomfort can also be observed in newborns. This imbalance, which disturbs the intercell signal connections in the brain, can be realized in the forms of anxiety, anger or fasting, which can in due course increase the negative emotions. This chemical imbalance is the background to behavior called *reward deficiency syndrome*. This syndrome also represents a deprivation of the brain mediator mechanisms. It can be manifested in different forms from mild to very severe.

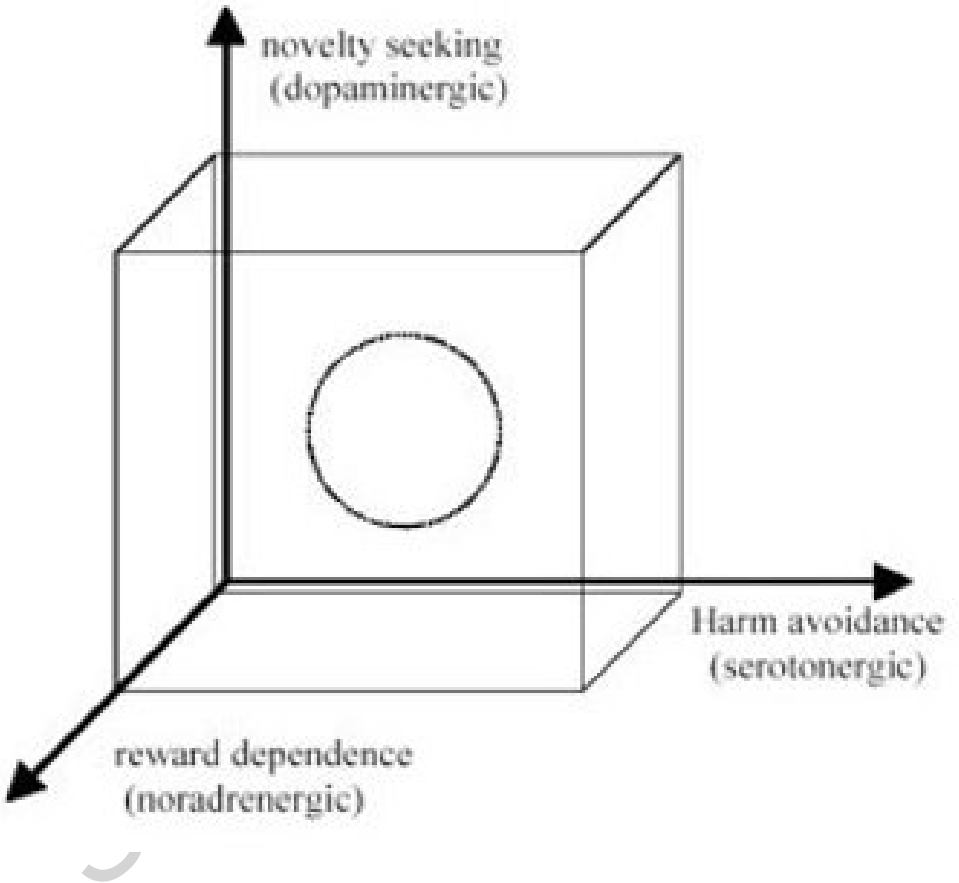

Figure 2. Cloningers's three-dimensional model of human personality

3.1. Dopamine Receptors

Kenneth Blum and al. (1976), supposed that there is a variant type of gene for the dopamine D2 receptor. There are five types of dopamine receptors (D1 to D5) with a special A_1 allele. The D2 receptor is coded by gene A which is located in the long Q arm of chromosome 11. The gene A is presented in four types of alleles, A_1 to A_4, of which A_3 and A_4 are extremely rare. The A_1 allele is present in 25% of the population, and the A_2 nearly in 75%. In the presence of the reward deficiency syndrome, complete

reversal of this proportion takes place— there are then more A_1 alleles then the A_2 alleles.

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Biographical Sketches

Richard Rokyta, Prof. MD, PhD, DSc. Professor of Physiology and Pathological Physiology, Chairman of the Department of Normal, Pathological and Clinical Physiology, 3rd Faculty of Medicine, Charles University, Prague, Czech Republic. He was born in 1938 in Užhorod, Czechoslovakia. He obtained degrees at the Medical Faculty of Charles University, Prague: Plzeň (MD), PhD and Associate Professor of Pathological Physiology, DSc of Normal and Pathological Physiology.

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Congresses organization: 1982 Praha Réunion Commune Societé de Physiologie – General Secretary; 1990 Praha – President Réunion Annuelle Societé de Physiologie, 1991 Praha - Regional Meeting IUPS – General Secretary, 1998 Praha Joint Meeting The Physiological Society and the Czech Physiological Society – President; 1999 Praha – Second Congress of FEPS – General Secretary, 2003 Praha IV.th EFIC Congress Praha – General Secretary. He received several international and national awards.

Anna Yamamotova, PhD, Associate Professor of Physiology was born in 1953 in Trenčín, Czechoslovakia. She obtained the following degrees: 1984 RNDr., Charles University, Prague; 1984 CSc. Czechoslovak Academy of Sciences, Prague; 2003 Doc. (Associate Professor of Physiology) Charles University Prague. She graduated in the Biological Faculty of Lomonosov University, Department of Physiology of Higher Nervous Activity, Moscow. Diploma dissertation work: "The conditioned motor reaction during the different stages of human sleep and its electrophysiological correlates". Then she worked in the Psychiatric Research Institute, Prague, where she defended a dissertation on the theme: "The study of the activation dynamics from the point of view of electrophysiological correlates of behaviour in laboratory rat". Her research interest was "Biological rhythm and activation dynamics in normal and pathological behaviour". From 1985 to 1993 she was working in the Institute of Physiological Regulations of the Czech Academy of Sciences. In 1990 she was visiting scientist in the Affective Disorder Team (under Prof. P. Grof) in Royal Ottawa Hospital, Ottawa, Canada. From 1993 to the present she was Assistant Professor and Associate Professor at the Department of Physiology and Clinical Physiology, 3rd Faculty of Medicine, Charles University, Prague. Her present interest is: common neurobiological mechanisms of pain, stress and food intake.