Biological mechanisms of human sexuality

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Abstract

A diversity of complex controlling factors as well as an abundance of ways in which human sexuality is expressed remains an important methodological problem which impedes a scientific description of the phenomenon in question. The paper introduces a concept of hierarchical modeling of human sexuality. Also presented are biological mechanisms of sexual response, which are discussed at various levels of detailed modeling.

Key words: hierarchical modeling, phenomenological model, human sexuality, biological mechanisms

Introduction

It is clear that from the earliest days of mankind, sexuality always stirred much interest. The evidence can be found in many relicts of drawings on the rocks from the times of primitive humanity, which depict, either real or imaginary, human sexual response. After thousands of years, human sexuality remains a challenge for sexologists and other researchers.

The basic obstacle in the process of preparation of a coherent model of human sexuality is the multiplicity of complex factors influencing sexual behaviors and responses as well as a compound system of interactions among these factors.

According to the concept of a hierarchical approach to the description of human sexuality (fig. 1), one can figure out several levels of its modeling.

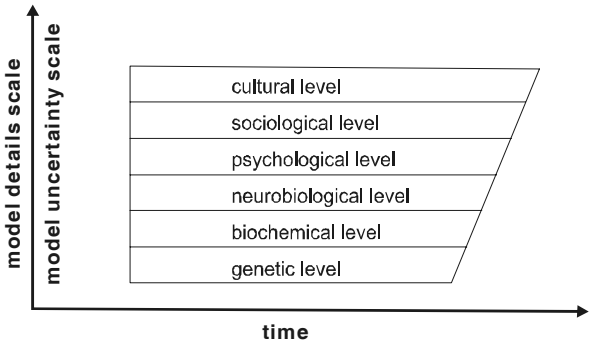

Fig. 1 The concept of hierarchical modeling of human sexuality

The higher the level of spatial and temporal generalization of a given model, the more processes influencing human sexuality are included.

However, as we know from methodology of modeling, the side effect of generalization always include increasing uncertainty and decreasing precision of the obtained description [1]. The cultural model, which stems from philosophical concepts and cultural traditions of a given social group and may be discussed in terms of various social categories, most frequently remains the basis for understanding human sexuality.

These are cultural models, which particularly depend on the family of one's upbringing.

The highest level of generalization of cultural models may mean that stereotypes functioning in a given social group, despite being incompatible to the models of lower levels, remain the basic contents of a model.

The models of a lower layer i.e. the sociological models describe sexual behaviors and responses in the context of social relations. As these models are created on the basis of sociometric methods, they are less uncertain then the cultural ones. Due to the fact that sociological models should be treated as a generalization of lower level models, some social behaviors can be proven to be biologically conditioned.

Psychological view on human sexuality concentrates mainly on explanation of the role of emotions and feelings in creating and in motivating of human sexual behaviors. Sternberg's triangular model of love [2] and various archetypes of love are typical examples of this class of models.

Until recently, the prevailing outlook in the science of sexology presented human sexuality in the light of cultural, sociological and psychological models.

It was the development of methodology of biological research and brain activity imaging which made it possible for sexologists to observe the processes caused by a sexual or psychosexual stimulus in a given person. These tools enable one to construct neurobiological or biochemical models of processes taking place in a given person, which describe well-defined and measurable processes governing human sexuality.

The attempts to explain the role of genes in physiology and pathology of human sexual response remain the newest trend in biological research.

The goal of this article is to present latest findings related to biological grounds of human sexuality, which are related to selected processes at various levels of description of human sexuality.

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Biological grounds of sociological models

The main goal of sociological research of human sexuality is to explain the mechanisms responsible for selection of a sexual partner and long-term interpersonal relationships. Currently in literature, there is a unanimous opinion that the decision to select a sexual partner does not only have an emotional component but also a cognitive one. Due to the fact that the selection of a partner is based on many criteria and depends on social norms of a given historical era makes it difficult to figure out biological mechanisms controlling selection of a partner. Nevertheless a few biological mechanisms playing a vital role in the selection of a sexual partner can be highlighted. The best known one refers to the fact that women prefer men who differ in the MHC system genes.

Wedekind et al. suggested that women were much more likely to select men who were carriers of a different HLA allele. However, couples with a similar allele pattern were observed to delay the decision to have a child . This discriminative ability seems to be increasing in the follicular phase of a menstrual cycle and appears to be dramatically decreasing in the lutheal phase.

On the contrary, females taking contraceptives were shown to select "genetically similar" males because these partners do not pose jeopardy for the "pregnancy" simulated by the pill [3]. Pheromones remain one of the postulated information carriers for genetic similarity. Also, male pheromones were shown to contain androgen derivatives androstenole and androsterone. This finding may at least partly explain why women much faster fall in love with domineering masculine males as this personality trait is connected with a higher androgen levels. Additionally, fatty acids, which are vaginal output contents, remain one of the ingredients of female pheromones. It is important to note that their concentrations and contents change during the menstrual cycle and may signal to a male that a high fertility cycle phase is coming soon. This hypothesis was confirmed by Doty et al., who showed that males judged the scent of an ovulating woman as more pleasant than the smell of a woman in the lutheal phase [5]. One must bear in mind, however, that due to so many advances in the cosmetics industry, any potential influence of natural pheromones may be very limited.

Another biological mechanism which is suspected to play a role in the process of partner selection is the attractiveness of the face and silhouette. According to Jonston's research findings, published this year, women looking for sexual partners tended to select males characterized by androgen anthropometry of the face. However, when these women were to choose a life partner and the father for their children, they women preferred less androgenic males. This relationship may be explained by unfavorable influence of androgens on man's health and his psychosocial relations. Furthermore, not only does androgenization trigger the development of aggressive personality which does not make one a good father but it also remains a risk factor in circulatory system diseases and leads to immune deficiency [6].

A similar relationship was observed in males, who tended to select more androgenic women for sexual partners, yet preferred less androgenic females as life partners. In the discussion it was suggested that masculine women were had less psychological ability to hold stable relationships [6]. Two diverse strategies of partner selection, influenced by the nature of the relationship seem to be another argument for the role of conscious rational processes in the selection of the object of love. Additionally, the mechanisms described above are certainly modulated by the elements of the cultural model. Establishing long-term relationships is another process studied at the level of sociological models. Researchers agree that the ability to form long-term interpersonal relationships is also controlled by hormones and neurotransmitters. Moreover, oxytocin, vasopressin and serotonin are thought to play the main role in this process. And yet, as animal studies show, this hormone is more important for females. Similarly as in women, its concentration clearly goes up during stimulation of the vagina, cervix and breast nipples and vasopressin seems to play a role of the "attachment hormone". The oxytocin and vasopressin synthesis was also shown to be stimulated by dopamine. One of the main reasons to team up and live in couples is the need to be safe and secure. As the results of experiments on animals show, oxytocin dramatically inhibits the activity of the hypothalamic-pituitary-adrenal axis (HPA axis), thus leading to the reduction of the stress hormone concentration [7]. Recently, there have been attempts to describe the role and action of oxytocin. Ferguson *et al.* have shown in their mice study that the bonding action of oxytocin may be connected with the amygdala excitation [8]. The lack of excitation of this brain area leads to incorrect evaluation of one's social relations, and, in the most extreme cases, may be one of an etiological mechanism of autism. Higher olphactory bulb and lateral septum oxytocin concentrations following a sexual intercourse correlate with the length of the relationship with the partner. Yet, the vasopressin research on mice shows that this peptide boosts sociological memory [9]. When analyzing the bonds between partners, one must also bear in mind that biological mechanisms may to a great extent be modified by cognitive processes which, in turn, are connected with social norms and moral reasoning, which is characteristic for the mankind. Further research will show the relation between a conscious decision to continue a relationship and the oxytocin-vasopressin system.

One might expect, however, that in the process of socialization of the sexual need, the functioning of the above described mechanisms is reconstructed so an individual may have an ability to make conscious decisions relating to relation with the selected person.

Biological grounds of psychological models

Psychological models of human sexuality focus on the role of emotions and the developing affection. Evolutionary psychologists claim that the ability to fall in love and to feel it is one of the mechanisms which motivate people to start

sexual relations [10]. Transcultural research findings confirm that the sensations of being in love are independent of social norms and philosophical concepts of a human being. Being in love, which is accompanied by strong excitement, also remains one of the plot- making elements in literature. Literary descriptions of being in love added to this experience so much magic and mysticism that it will always remain beyond rational cognition. In particular, contemporary mass culture promotes the pattern of romantic love, which is completely independent of reasoning and cognitive processes. However, even in the classic literature one can find descriptions of being in love which are compatible with contemporary psychosexology and the excellent description of passion of Maria and Robert Jordan in Ernest Hemingway's "For whom the bell tools" can serve as an example. Current psychological models, which focus on explanation of neurobiological grounds of emotions connected with being in love and the affection of love, point to brain system of punishment and reward, which is a functional system consisting of a few scattered centers involving fronto – cortical centers, the limbic system and the nucleus accumbens (fig. 2).

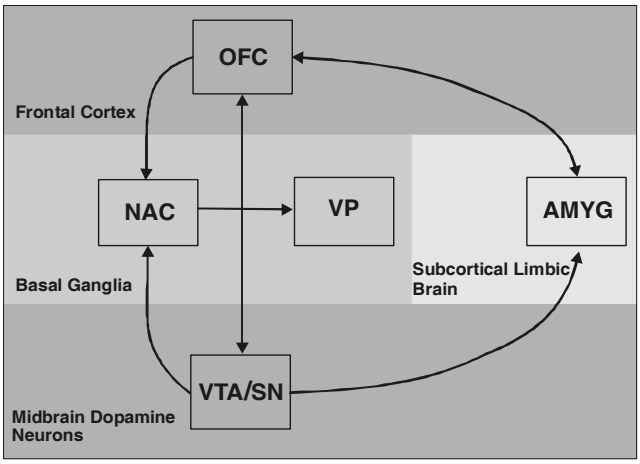

Fig. 2. The structure of the reward system (OFC – fronto-occipital -cortex, AMYG – amygdala, VTA/SN – ventral tegmental area/black substance, NAC – nucleus accumbens, VP – ventral pale globe)

The reward system contains mainly dopaminergic, GAB anergic and serotonergic neurons [11]. The research study by Bartels and Zeki, which was conducted with the use of functional magnetic resonance, has shown that whenever people in love are shown a photo of the person they are in love with, their reward system brain centers are being aroused.

This system can also be aroused by other stimuli such as financial rewards or delicious food [12]. The same authors have also demonstrated subsequent inhibition of activity of centers responsible for evaluation. These findings are somehow confirmed by a popular wisdom, which claims that a man can be seduced with excellent food while a woman – with gifts. Reduced ability to assess is, in turn, depicted in the old saying that love is blind. The arousal of the reward system triggers synthesis of dopamine, which in turn boosts catecholamine secretion. This mechanism seems to be particularly responsible for subjective feeling of being in love. Possibly, due to the fact that being in love also means being under stress, human beings function worse in tasks which demand attention. This simple model of developing love would be incomplete, if it had not included the role of prefrontal cortex in the process of growing affection. Recent discoveries in neurobiology of human emotions make one think that cognitive processes in this area of cortex may inhibit the response of dopaminergic system to sexual stimuli. Moreover, emotional memory can to a great extent modify the reward system response to a given stimulus [13]. In the light of latest findings, one may hypothesize that the state of being in love not only alters the activity of one's brain but it can also modify the neuron structure. Enzo et al. has shown statistically significant increase in the neuron growth factor in people in love compared to people who are not in love [14]. Furthermore, the concentration of the aforementioned factor correlated with the power of the subject's feelings. Current models of psychological determinants of human sexuality support the hypothesis that even romantic love does not exist independent of one's will and does not have to lead to development of social bonds.

Biological grounds of sexual responses

Despite the fact that sexual responses have biological grounds by nature, a coherent model explaining biological regulation of these responses has not been discovered yet. Up to the end of the 20th century a phenomenological Masters and Johnson model, later completed by Kaplan, was in use. This model assumed identical, linear dynamics of sexual response both in the human male and in the female, which consisted of the phase of sexual desire, the phase of sexual arousal, the phase of plateau, the phase of orgasm and the final phase of resolution [15]. If, in order to clarify the idea, one assumes this model is a classic description of sexual response, one can demonstrate that while the phase of excitement has been most thoroughly described, the mechanism of development of orgasm remains the most obscure one. The least number of research studies have been devoted to biological grounds of the phase of desire. These differences are caused by the fact that only an accidental report of the influence of Sildenafil on men's ability to have an intercourse gave muscle to the progress in the research o biology of human sexual response. Earlier studies, which were more of a descriptive character, were limited to analysis of peripheral responses accompanying sexual intercourse. Nowadays nitric oxide-induced vasodilation of vessels providing blood to penis, vulva and labia remains the best described mechanism of sexual response. As those mechanisms are often described in the literature on pharmacodynamics of phosphodiesterase type 5 inhibitors, they will be omitted in this paper. Due to the fact that objective measurement of sexual response in the human male is easier, most models in literature refer to men.

In accordance with the model proposed by Steers, erection inducing impulses may come from visual and auditory

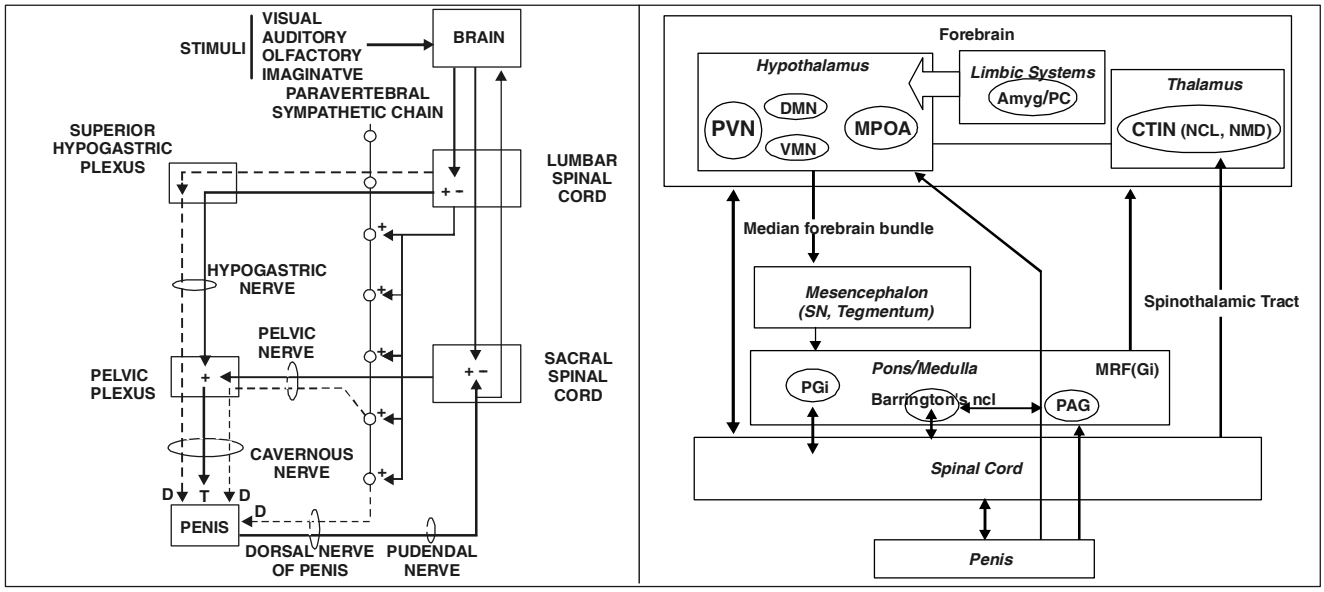

Fig. 3. Peripheral and central nervous tracts controlling erection of the penis. mPOA – medial-preoptic and anterior, VMN – ventromedial nucleus, DMN dorsomedial nucleus, PVN – paraventricular nucleus, Amyg – amygdaloid complex, PC – pyriform cortex, CTIN (NCL, NMD), caudal thalamic intralaminar nuclei (nucleus centralis lateralis, nucleus medialis dorsalis), MRF – medullary reticular formation (nucleus reticularis gigantocellularis) [17]

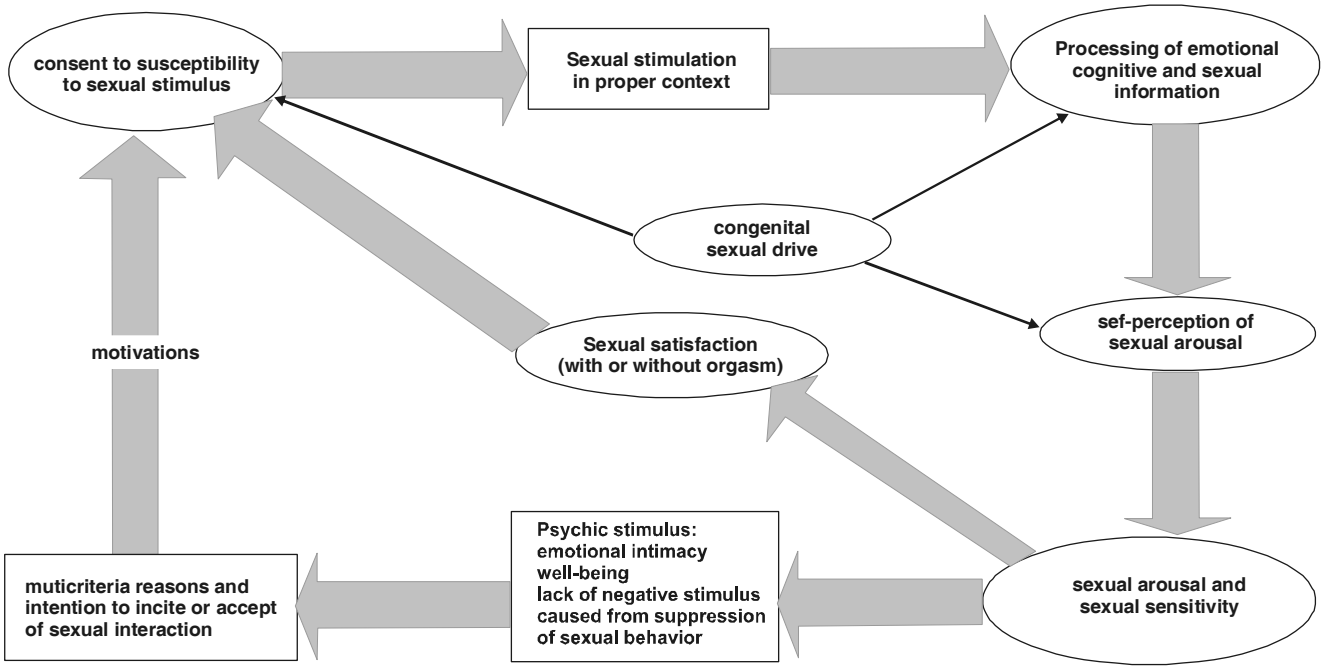

Fig. 4. A phenomenological model of sexual response in the female suggested by Basson [16]. Ellipses describe the states of sexual response while the rectangles refer to stimuli which enable transition between given states

centers of the brain, thalamus (touch stimuli) and the limbic system (imagery). In picture 3 you will find a description of peripheral nervous tracts transmitting erection inducing impulses and junctions between central nervous system centers [15].

One can clearly see that dopaminergic neurons, which may be regarded as a mediator with the model of "falling in love", also participate in the erection regulation process. Because visual stimuli are the most worthwhile for males, emotional commitment is not necessary to achieve sexual arousal.

So far, the results of the research of sexual response in the female do not let us suggest a model of biological mechanisms which induce these responses. One of the reasons refers to the fact that yet another phenomenological model of sexual response in the female had been suggested. Big cohort gender

stratification research studies positively verified the Masters and Johnson model only with regard to sexual response in the male. As far as women were concerned, the model was rejected because women were found to have a more complicated, non-linear dynamics of sexual response. The results of the research gave way to another model of sexual response dynamics in the female. The model, which was suggested by Basson is presented in picture 4 [16] and assumes cyclic dynamics of sexual response in the female including positive feedbacks between psychosexual stimuli and cognitive control of sexual response. As opposed to the Masters and Johnson model, which regards sexual stimulus as sufficient to induce sexual response, Basson claims that a woman must be "ready" to adequately receive and interpret a sexual stimulus. This is why women are able to exert more control over their sexual responses, i.e. by negative interpretation of sexual stimuli they receive. Feedbacks in the sexual response dynamics suggest that women may transfer from one phase of sexual response to another, omitting some of the phases in between. A new phenomenological model of sexual response in the female creates new goals for research studies on its biological mechanisms. Based on this model, one may conclude that the key to understand the biology of female sexuality is a model including psychobiological, neurophysiological and hormone mechanisms. So far, all the findings remain fragmentary, which makes one unable to discover a biological model of female sexual response.

Another obstacle to the progress in the research of female sexuality is connected with inability to make objective measurements. Additionally, cyclic dynamics of female sexuality also refers to the fact that sexual hormones to a great extent modify female sexual response. The results of the study by Park *et al.,* which was conducted with the use of functional magnetic resonance, suggest that both in men and in women, same parts of brain are active during response to sexual stimuli [18]. Recently, however, a more precise investigation by Gizewski et al. have shown increasing activity of limbic system areas in women in periovulation phase compared to menstruating women [19]. Recent studies point to an important role of prolactin in the phase of resolution, connected with its higher concentration following an intercourse. Inhibitory influence of this hormone on dopamine synthesis may explain lowered tension and euphoria following intercourse. Also, prolactin has been found to have a calming effect on the ability to erect penis [20].

Final notes

Advances in imaging technology and methodology of clinical and experimental research made it possible to learn more about biological grounds of human sexuality. Hierarchical approach to a description of complex mechanism of sexual activity, as suggested in this article, makes it possible not only to arrange knowledge but also to notice complimentary relations between sociological, psychological and biomedical outlook on human sexuality.

The progress in biological research on regulatory processes of sexual behavior fosters medicalization of clinical sexology, which in turn often enables effective treatment of sexual disorders. Biological mechanisms described in this paper give evidence that some sexual dysfunctions may be of genetic origin expressed by quantitative or qualitative lesions of neurotransmitter receptor or its synthesis. On the other hand, one may suggest that the influence of social, cognitive and emotional processes on sexual functioning supports the role of psychotherapy used as a complimentary form of treatment of sexual dysfunctions.

It seems especially important to include cyclic model of female sexual response in clinical practice, which enables one to control the quality of a woman's sex life by modification of her cognitive and volitional processes.

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