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Ion G. Motofei
Carol Davila University, Department of Surgery and Psychiatry, igmotofei@yahoo.com

David L. Rowland
Valparaiso University, Department of Psychology, david.rowland@valpo.edu

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Structural dichotomy of the mind; the role of sexual neuromodulators

[1]*Ion G. Motofei*, [2]*David L. Rowland*

[1]Carol Davila University, Department of Surgery and Psychiatry, [2]Valparaiso University, Department of Psychology

Abstract

The mind (mental function) and sexuality represent two distinct environmental functions, but which are supported within the brain by a common (somatic-autonomic) neurobiological substrate. As a consequence, mental function takes on autonomic characteristics from the sexual-autonomic system (like autonomy, duality), while sexual function takes on features from mental functioning (such as lateralization). In this paper we discuss the lateralized action of two classes of sexual neuromodulators: hormones and pheromones. This process of lateralization is assimilated with the structural dichotomy of the mind.

A relatively similar process but related to informational dichotomy of the mind will be presented in a forthcoming paper. Structural and informational dichotomies of the mind represent essential aspects that need clarification in order to continue the solving of the mind-body process, a work in progress articulated through a succession of papers.

Keywords: structural dichotomy, the mind, sexual hormones, sexual pheromones, lateralization, hand preference

Corresponding author: *Ion G. Motofei*, Carol Davila University, Faculty of General Medicine
e-mail: igmotofei@yahoo.com

Introduction

Sexuality is a complex bio-psycho-social process in humans, which relies on the involvement of specific neuro-endocrine/ erogenous modulators (hormones and pheromones) for activation and response. The erogenous role of sexual hormones is fairly well documented in the research literature, from both physiologic and pathologic perspectives (1). In contrast, a potential implication of human pheromones in sex-based neuro-biological mechanisms and the corresponding sex-related behavioral responses are still an ongoing study, with most initial data regarding these odiferous sexual compounds obtained through non-human studies (2).

Our previously published work posited that the human mind exists independent of the physical body, and that this human specific mental existence/ entity takes place within the brain where it interacts only within the context of an internal mental (cognitive or sexual) reality. This mental information can be internally derived—for example through memory or imagination—or result from a procession of external information under action of cognitive and sexual neuromodulators (3, 4).

To explain the functioning/ role of sexual neuromodulators and to differentiate between the roles of hormones and pheromones, it is necessary to present both the structural (in this article) and the informational (a forthcoming paper) dichotomies of the mind.

Discussion

From an anatomical perspective, the human brain is delineated by the median plane into two distinct/ symmetrical hemibrains. Usually, each cerebral function is processed in only one hemibrain (referred to as dominant), the other hemibrain serving mainly for neurological connection between the dominant hemibrain and the peripheral receptors/ effectors. Such asymmetrical functioning of the brain (known as lateralization) is well documented for multiple cerebral functions such as hand preference (5), language (6), memory (7), emotion (8), sexuality (9, 10), etc. In support of this, the lateralization of cognition, for example, favors deployment of multiple psychological tasks enhancing cognitive abilities (11), while decreased or aberrant hemispheric lateralization predisposes to poor cognitive functioning or even mental disorders like schizophrenia, bipolar disorder, ADHD, etc. (12, 13).

The lateralization process of the brain appears to have a genetic component, being physiologically possible through intervention of several/ different relational neuromodulators, which channel the environmental information within the brain towards either the left or the right hemibrain (14). Without such channeling, the two distinct hemibrains would receive, process, and elaborate two distinct (possibly competitive, if not contradictory) responses to the same external stimulus/ information, a situation that, from a physio-psychological perspective, would be inefficient and even counterproductive (3, 4).

Sexual hormones modulating sexuality on a lateralized basis

Several studies show that estrogens likely modulate environmental inputs predominantly in left handed subjects, either male or female. Accordingly, women who are prenatally exposed to diethylstilbestrol (a synthetic estrogen) are more likely to acquire afterwards (for writing) a left hand preference (15). In support of this, administration of Tamoxifen (an antiestrogenic compound) seems to decrease sexual function predominantly in left handed men (16). The competitive/ opposite class of hormones, namely androgens, appear to channel the same environmental inputs especially in right handed persons towards the opposite/ competitive hemibrain (17). In support of this, administration of Bicalutamide and Finasteride (antiandrogenic compounds) decrease sexual function predominantly in right handed men (9, 10). From an evolutionary perspective, cortical maturation during puberty involves especially the left hemibrain in human males, and the right hemibrain in human females (18, 19, 20).

Olfaction and pheromones in humans

Pheromonal signals are essential for the perpetuation of many animal species, acting as neuromodulators within the brain in order to ensure the finding of an eligible mate and further the initiation of the necessary sexual reflexes/ responses (2). Humans have traditionally been considered having an olfactory sense inferior to other mammals, the olfactory receptors being underexpressed due to the fact that about 70% of the corresponding genes became nonfunctional during evolution (19). As a consequence, olfaction has generated little interest within the study of human sexuality until fairly recently (20), especially since the vomeronasal organ (specialized in animals for pheromone detection) seemed to be vestigial in humans (21). This restricting perspective had been reinforced by the idea that human sexual response is strongly linked to and governed mainly by visual cues (22). However, during the past 20 years substantial data have accumulated, implicating pheromones in humans, not only with regard to gender and sexual orientation (23, 24) but also with respect to the behavioral, neurophysiological, and endocrinological roles of these odoriferous compounds (25; 26, 27). Accordingly, a number of authors now believe that the role of human sexual pheromones had been underestimated by the medical sciences and that the implication of olfaction in sexuality deserves reconsideration (22, 28, 29).

Classically, mammals have two distinct olfactory systems: the main olfactory system (that originates in the main olfactory epithelium) designed for recognizing common/ general odorant molecules, and an accessory olfactory system (that originates in the vomeronasal organ) responsible for detection of pheromonal compounds conveying sexual cues/ signals (21, 22, 24). The two olfactory systems send afferent impulses to the brain via distinct input routes (25, 26, 27, 28), such that the two distinct information(s) are processed in

different brain centers so as to induce distinct behavioral and neuro-endocrinological output responses (29, 30, 31). In fact, recent studies on mammals show that not only the vomeronasal organ but also the main olfactory epithelium are actively involved in pheromonal communication (32, 33). In other words, the main olfactory system of mammals detects both general odors and pheromonal molecules as distinct chemosensory information, which are then sent either to the main olfactory brain for general olfactory processing (namely to amygdala, piriform, orbitofrontal, insular and cingulate cortex) or towards the accessory (hypothalamic) olfactory brain for pheromonal/ sexual signal processing (29, 34, 35). It has been argued that the function of the accessory olfactory system has been absorbed in humans into the main olfactory system (29). As a consequence, activation of the hypothalamus by pheromones seems to be possible in humans even when the vomeronasal organ is occluded (36).

In addition, humans could detect sexual pheromones not only through the main olfactory epithelium/ system (according to mammalian studies) but also through a specialized chemosensory epithelium, which is unique to the human body and, from an anatomical perspective, corresponds (according to electron microscopy studies) to a vomeronasal organ (37). From here, pheromonal signals could be sent to the brain through a designated nerve (referred in humans as the *nervus terminalis*). This nerve, an additional cranial nerve implicated in reproductive behavior, had not been recognized when cranial nerves were first numbered (29, 38). Furthermore, new anatomical evidence supports the idea that the vomeronasal organ could yet have a certain activity/function in humans (2).

In support of pheromonal communication among humans, studies have shown that the human body produces pheromone-like signals, that the human nose can detect such signals, and that such signals have the potential to modulate behavioral and endocrine reactions (29). Specifically, human sexual pheromones induce among opposite gender individuals specific endocrinological responses, and subsequently behavioural changes involved in the initiation of romantic courtship. Thus, male pheromones like androstenol and androstenone (from male sweat) seem to have a direct impact on the female menstrual cycle, making it more regular (28, 39), presumably by modulating the timing of ovulation through increasing frequency of pulsatile LH secretion (26). Moreover, women smelling androstadienone (also from male sweat) presented a higher level of the salivary hormone cortisol (40). In turn, female pheromones like copulins (from vaginal secretion) may induce hormonal changes in males, thereby modulating male perception of females (28). Such hormonal changes have also been related to female axillary pheromones from T-shirts of ovulating women, thereby inducing higher levels of testosterone in exposed men compared to men either exposed to the scent of non-ovulating women or to a control scent (41).

Pheromonal signals modulating sexual activation on a lateralized basis

Based on the existing literature, sexual pheromones are implied in humans not only in the neuroendocrine processes of the brain related to finding an eligible mate, but also directly in sexual activation and response, modulating the cerebral processes of sexual drive/libido and sexual arousal (39, 40, 41). As an example, the male sexual pheromone androstadienone has been demonstrated to increase the physiological level of arousal in women, having a sympathetic-like effect (42). Moreover, human male sexual pheromones seem to be important also for men—in heterosexual men, for example, increasing their sexual attractiveness and motivation to initiate socio-sexual behavior with women (43). At the same time, female sexual pheromones are important for both men and women, being able to increase, for example, sexual attractiveness of women to men (44). In summary, some men and women may be dependent primarily on male sexual pheromones, while other men and women may be dependent primarily on the opposite class of (female) sexual pheromones (1, 16, 21). Such patterns are conceivable if the genes encoding the dominant hemibrain (namely the pheromonal class that activate it) are different from the genes encoding the person's gender (25).

In support of a lateralized action of sexual pheromones, literature data suggest that the process of sexual activation implicates participation of the right hemibrain (right hippocampus, right parahippocampal gyrus, etc.) in *heterosexual* men (sensitive to female pheromones), while the process of sexual activation implicates the the left hemibrain (the left angular gyrus, left caudate nucleus, etc.) in *homosexual* men (sensitive to male pheromones) (45). According to other studies, heterosexual men and homosexual women (lesbians) present a rightward volumetric cerebral asymmetry (with connections which are more widespread from the right amygdala), while homosexual men and heterosexual women present connections that are more widespread from the left amygdala (46). Other data also show that homosexual and heterosexual men differ with respect to the sizes/ volume of hypothalamic nuclei (47).

Perspectives

The results of these and related studies suggest a number of new avenues for investigation. If androgens are generally more important for sexual activation in right handed persons, estrogens might be more important for sexual activation in the opposite hemibrain/ left handed group (15, 17). Interestingly, the incidence of breast cancer is higher in left handed/ estrogen dependent persons (48). Yet these estrogens may intervene not only in sexual function but also in cognitive/mental function (49, 50), perhaps manifested by the fact that depression is typically more commonly encountered in women than men (51). Furthermore, the incidence of depression is higher in left handed persons who present a hyperactive right-

hemisphere, due perhaps to an excessive/ inadequate activation of this lateralized structure (52). Reproductive-related depression (premenstrual depression, postpartum depression, and climacteric depression) is usually treated with transdermal estrogens (the first-choice therapy rather than antidepressants) (53, 54). Yet, in postmenopausal women, testosterone administration not only improves libido in some women but also decreases the incidence of breast cancer, due perhaps to its antiestrogenic effect (55, 56). Thus, when viewed as a possible cognitive-sexual interrelated disorder, depression can be better understood; for example, depression in men is correlated with both the psychological and physical aspects of sexual dysfunction (57).

Conclusions

The research literature (clinical and imaging studies) shows that sexual neuromodulators-hormones and pheromones- modulate the brain through a lateralized action, channeling information from the environment towards either the left or the right hemibrain. This anatomical dichotomy is necessary to avoid simultaneous processing of environmental information in both (left and right) hemibrains, and thus to avoid generation of two distinct (possibly competitive, if not contradictory) responses to the same external stimulus/ information.

Summarizing, androgens and female pheromones would activate the right hemibrain, while estrogens and male pheromones seem to activate the left hemibrain. New investigations are therefore essential to establish whether androgens and female pheromones have either synergistic or competitive actions on the right hemibrain, a similar question also being relevant regarding the actions of estrogens and male pheromones within the left hemibrain. To clarify these aspects it will be necessary to first address aspects of the informational/mental dichotomy of the brain (perhaps in forthcoming paper), and to integrate it with structural dichotomy of the brain presented above.

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