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Human Voice Took Over the Role of Pheromones in Establishing Sexual Orientations

Yehuda Salu, Department of Physics and Astronomy, Howard University, Washington, DC 20059. yesalu@gmail.com

ABSTRACT

The biology of sexual orientations has intrigued people for generations. Many models have been providing insights to that topic, but there are still unanswered questions. In humans, sexual orientation has a learned component. Humans have to learn cues by which they identify the sex of their mates, and cues of the emotional messages that those mates broadcast. Many of those cues depend on arbitrary societal conventions. The cues are learned automatically and subconsciously during childhood, based on non-sexual experiences. When sexual orientation emerges at puberty, the youngsters cannot tell how and when they have acquired it. A model that deals with those phenomena is presented. A basic tenet of the model is that a sexual orientation is determined by the innate wirings of the brain. The model describes how the brain learns cues for identifying the sex of the mate, and cues for identifying emotional messages that the mate broadcasts. The learning mechanism is conditioning. The unconditioned stimulus is human voice. The unconditioned responses are the triggers of the physical and emotional manifestations of sexual activity. The model suggests that innate connections from auditory detectors of men's and women's voice onto brain centers that trigger sexual activities, such as the hypothalamus, determine the sexual orientation that emerges at puberty. Innate connections from those auditory centers to emotional centers, such as the amygdala, determine the learned emotional cues. It is also proposed that during evolution, the roles of the chemosensory system in identifying mates were taken over by the auditory system.

Key words: Voice and sexual orientation; Human sex pheromones; Evolution of sexual orientation; Development of sexual orientation; Puberty; Causes of sexual orientation; Biology of sexual orientation

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INTRODUCTION

(In the following, mate will mean sexual mate. Arousal will mean initial sexual arousal that accompanies the selection of a mate. Arousal usually increases as the interaction progresses, and it is caused by various underlying mechanisms.)

Animals continue to grow after their birth. Their systems continue their development in synchronized sequences. Their sensory systems, such as the vision, adjust to the external conditions, their motor abilities and their feeding skills are perfected, and they learn to find their way in their physical and social environments. Only then their sexual systems mature. In some animals, the sexual system is "nature" (innate, inherent); its development is completely pre-determined. In other animals, including humans, the sexual system is "nature and nurture"; some of its development is guided by individual experiences.

Animals operate in several states-of-mind that can be switched on and off. Hormonal levels and general information about the self and the surroundings affect that on/off switching. One of those states-of-mind is sexual. Once that state is on, the animal can enact a sequence of activities that include selecting a mate, arousal, approaching each other, aligning the bodies, stimulating the sex organs, and copulating. There are internal rewards with various degrees of intensity in each stage of the sexual interaction. Each stage sends coordinating signals to the following stages.

At puberty, the sexual state-of-mind is switched on, at the background or at the forefront. Human pubescents discover new feelings and sensations that they have not felt before. Without knowing why and how, people of a certain sex attract and arouse them. The youngsters identify those people based on cues that those people broadcast. Quite often, some of those are arbitrary visual cues that are typical to their society, such as clothing and general appearance.

During their childhood, the youngsters have developed, subconsciously and on their own, the ability to identify mates and to be aroused. Apparently, their brain has been using inherent learning mechanisms that enabled them to develop that ability.

Conditioning

Conditioning is an inherent learning mechanism that was first studied in the feeding behaviors of dogs. It has since been shown to affect many other behaviors of numerous species. It operates on sensory, emotional, and cognitive stimuli. It is a basic tenet of behaviorism and it explains complex behavior patterns. While conditioning in humans usually takes place as the subject is conscious, the learning happens subconsciously. Subjects may not be aware that they have learned something. The realization may come long after the learning has ended. Skills that were learned subconsciously in childhood may pop-out later in life.

In conditioning, the brain learns new behaviors based on older behaviors that are paired with associated new experiences. An older behavior that consists of an unconditioned stimulus (**US**)

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and its unconditioned response (**UR**) occur together with a conditioned stimulus (**CS**). As a result, future occurrences of the **CS** will trigger the **UR.** For example, a piece of meat on the tongue of the dog (the **US**) triggers salivation (the **UR**). At the same time a bell rings (the **CS**). After conditioning, the bell's ring by itself will trigger the salivation. After the **CS** has been learned, it may serve as the **US** in other learning settings. There are other paradigms of conditioning. Using conditioning, the brain can develop elaborate information structures based on a few, innate, hardwired concepts.

The behaviors that an animal can learn by conditioning is determined by the innate brain wirings between the **US**'s and the **UR**'s, and by the stimuli that are amenable to conditioning. It is plausible that the child's brain uses conditioning for learning its sexual activity plans.

Sexual behaviors involve two individuals that need to exchange information in order to coordinate their activities. The animal kingdom's most fundamental means of exchanging information is by chemical signals (Mucignat-Caretta, 2014; Pause, 2017). A message that one partner has to send to the other is encoded by a specialized chemical. The body of the first animal produces that chemical and broadcasts it. The second animal picks it up, and its internal structures responds to it accordingly.

Pheromones

Pheromones are chemicals that animals use for exchanging information, including for mate selection and arousal. Individuals solicit their availability by releasing pheromones that are picked up by potential mates and guide them to the solicitor. Once they meet, they exchange pheromones or other signals to affirm their sexual compatibility. Then, they become sexual partners. It is believed that most pheromones are innate (Wyatt, 2014).

The following discussions deal with sex pheromones whose production and release by the emitter and their pickup and internalization by the perceiver are innate. Those processes are carried out by organs and tissues whose structure and modes-of-operation are encoded by genes. In principle, pheromones could serve as the **US**'s when humans are being conditioned to identify mates based on the mates' associated **CS**'s, such as by the arbitrary visual features that distinguish between the sexes. For that to happen, human pheromones, if they exist, have to be present before puberty, and they need to be robust in the child's noisy surroundings, in order to assert their influence on the developing behaviors.

VNO

In many species, the vomeronasal organ (VNO) is responsible for detecting sex pheromones and forwarding their significance to other brain centers. Vomeronasal pheromone perception begins by the binding of pheromones to pheromone receptors located on the cell membrane of sensory neurons of the VNO, which triggers a signal transduction pathway that ultimately leads to the activation of the hypothalamus.

In addition to pheromones with direct relationship to sexual activities, depending on the species, the VNO can pick up pheromones that convey information about threat, feeding opportunities and other life sustaining situations.

Other organs are also involved in the transduction of social chemo-signals. These are: the primary olfactory system that can handle a wide variety of chemo-signals; the trigeminal system that processes pungent, irritant, volatile molecules; the Gruenberg ganglion (GG), which is implicated in detecting alarm pheromones emitted by stressed conspecifics, and scents released from predator urine (Brechbühl, 2008); and the trace-amine associated receptors (TAARs), that function as vertebrate olfactory receptors that mediate aversion or attraction towards volatile amines such as a predator odor or death associated cadaver odor (Liberles, 2015; Pause, 2017). The VNO in humans develops during the first 10-15 weeks of gestation, and then it deteriorates. The genes that code for vomeronasal receptor proteins and the specific ionic channels involved in the transduction process are mutated and nonfunctional in humans. In addition, no accessory olfactory bulbs, which receive information from the vomeronasal receptor cells, are found. The vomeronasal sensory function is thus nonoperational in humans (Trotier, 2011).

While the responses of other animals' functioning VNO to sex pheromones are robust and unmistakable, no such chemicals nor such responses have been found in humans (Savic, 2014a).

However, it was found that certain steroids, the "Putative Human Sex Pheromones" (PHSP), such as androstadienone, estratetraenol, estratetraenyl acetate, and pregnadienedione, affect humans in ways similar to sex pheromones. Those chemicals are found in bodily fluids of sexually mature adults such as in sweat, semen, and vaginal secretions. When inhaled, those chemicals activate brain centers that are involved in sexual activities, such as the hypothalamus (Savic, 2002, 2010; Lundstrom, 2006; Zhou, 2008; Frasnelli, 2010).

People describe sexual-like sensations that those chemicals induce in them. Male raters judged the odors of T-shirts worn during the follicular phase of women as more pleasant and sexy than odors from T-shirts worn during the luteal phase (Singh, 2001).

In some cases, inhaling those chemicals interferes with the menstrual cycle (Stern, 1998).

The details of those responses depend on the sex of the responders and on their sexual orientation (Savic, 2014b).

Put together, the prominence of the VNO in other species as the organ that senses the sex of potential mates, its deteriorated state in humans, and at the same time the marginal effects of the PHSP, which do not seem to be strong enough to alter sexual behavior in an automatic way, may indicate that the human VNO and the PHSP are evolutionary vestiges of a chemosensory system, that has been taken over by another sensory system.

The processes of mate identification and arousal in humans have learned components. They rely on cues that may vary from place to place and from time to time. The learning, which takes place during childhood, is subconscious and is accomplished by innate learning mechanisms. If human sex pheromones do not exist, or at best they are not very effective, then which sensory system provides the **US**‘s that could initiate and guide the subconscious learning of the arbitrary **CS**‘s that serve as cues for mate identification and arousal?

THE MODEL

Learning sexual orientation

It has been suggested that the human voice is the unconditioned stimulus that infants use for learning to distinguish between men and women (Salu, 2008, 2011, 2013, 2020). However, before they learn to distinguish between men and women, babies learn to identify humans, and they do it through various stimuli. Certain rewarding stimuli that are generated by their caregivers such as food, safety and the likes (the **US**‘s) trigger the learning of associated features of the caregivers such as eyes, mouth, human silhouette, etc. (the **CS**‘s) Those are some of the cues that children and adults use for identifying humans. Then, children learn on their own to differentiate between categories of humans such as children and grownups. Later, they learn to differentiate between men and women, and the **US** that guides them is apparently human voice: Men are those humans that have the low pitch voice; women are those humans that have the high-pitch voice. Features that are associated with low pitch voice become cues for the new concept ‘men’, and features that are associated with high pitch voice become cues for the new concept ‘women’. After that, children learn to identify mates; a skill that they will use at puberty. They learn cues of people that will attract them sexually. Some of those cues point to the sex of the mate; others carry emotional messages. That combination of cues would trigger at puberty their attraction and arousal. Children learn both kinds of cues subconsciously and automatically based on non-sexual experiences, by using inherent learning mechanisms, such as conditioning.

The voices of men and women are the external **US**‘s that children use, first to learn how to distinguish between men and women, and then how to be attracted and aroused by one of the sexes (or by both). The voices of women and men are inherent. They are robust and universal. Children have inherent detectors that can distinguish between voices of men and voices of women, due mainly to their pitch differences. Those are the detectors of the **US**’s. It has been suggested (Salu, 2008, 2011, 2013, 2020) that they are inherently connected to the brain centers that trigger sexual activities, such as centers that regulate tumescence and its associated feelings. Those triggers of sexual activities are the **UR**’s. Since the sex organs of children are not yet functional, the organs cannot yet be triggered, but the triggers themselves can participate in conditioning processes.

The innate connections between those **US**‘s and the **UR**‘s vary among children. In some children, detectors of men’s voice are connected to the **UR**. In others, detectors of women’s voice are connected to the **UR**. Those innate connections determine the sexual information

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structures that evolve during childhood, and eventually, the sexual orientation of the child when she/ he reaches puberty:

A child whose detectors of men's voice are innately connected to the sex activation centers will be sexually attracted at puberty to men. (Such a boy will become gay; such a girl will become straight.)

A child whose detectors of women's voice are innately connected to the sex activation centers will be sexually attracted at puberty to women. (Such a boy will become straight; such a girl will become lesbian.)

Arousal emotions

The identification of a mate depends on his/her sex plus other features, many of which create emotional reactions. Only persons who possess all the required features would qualify as potential mates. Those features are detected based on the emotional cues that the mate broadcasts. The emotional cues have to be learned the same way as the sex cues. Based on comparing the arousal emotions across sexual orientations, it was proposed (Salu, 2008, 2011, 2013, 2020) that the same emotions are shared by all sexual orientations. They consist of a combination of two basic emotions: apprehension or caution of the mate, and at the same time feeling safe, or wanting to feel safe with the mate. The mixture of these two opposite emotions creates sexual arousal. The proportions of those two basic feelings may vary from person to person, and they may vary with time in each person.

The child learns those emotional cues subconsciously by conditioning from no-sexual experiences. A typical and very common learning event would consist of an adult of the appropriate sex who evokes apprehension in the child while the child feels safe e.g. because of a nearby caregiver. (The sex of that adult would be determined by the innate connections from the auditory to the sex activation centers in the child's brain.)

The emotional component of the US is a combination of two inherent emotions: being cautious and apprehensive of a person, while at the same time feeling safe with that person. The combination of those two opposite emotions creates the pleasant rewarding feeling of arousal.

Sexual interaction is about allowing another person into one's domain and/or entering into the domain of another person. Both situations have an element of risk in them, but also the possibility of being rewarded by feeling safe. Pubescents feel it naturally. The wiring of the innate brain "anticipates" that feeling of the pubescent and turns it into a trigger of arousal.

Those feelings are handled by the amygdala and its related centers. Apparently, connections between auditory centers that differentiate between women's and men's voices, sex activation centers such as the hypothalamus, and the amygdala carry the information that is exchanged in learning to identify a sexually arousing mate (Salu, 2008, 2011, 2013, 2020).

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Evolutionary perspectives

Understanding evolution helps us understand present day biology. Chemical signaling has been probably the fundamental modality for coordinating sexual interactions. In the evolution process of some species, the visual system has taken over some of the roles of the chemosensory system. There are several evolutionary differences between old world monkeys (OWM) and new world monkeys (NWM), which affect their reproductive modes-of-operation (Dixson, 1983; Zhang, 2003). Genes encoding the TRP2 ion channel and V1R pheromone receptors, two components of the vomeronasal pheromone signal transduction pathway, have been impaired and rendered it dysfunctional in OWM and hominoids since shortly after the separation from NWM, 23 million years ago (Zhang, 2003). Another evolutionary difference is the duplication of the X-chromosome-linked red-green-opsin-gene, which also occurred in the common ancestors of OWM and hominoids after they were separated from NWM. This may have led to the emergence of trichromatic vision in both sexes, in contrast to the situation before the duplication, when only females may have had it, due to the existence of polymorphic alleles at the red-green opsin locus. Whether the relationship between the two changes is coincidental or part of an evolutionary interaction is debatable, (Gilad, 2004; Matsui, 2010). But “Future studies of the sensory cues involved in detection and selection of food … or the choice of a mate, may test this association directly” (Gilad, 2004).
There are some cases in which the auditory system took over some of the roles of the chemosensory system. Pheromones that are detected by the VNO are used by some species as warning signals of threats, for example the nearby presence of a predator. Animals with advanced vocal-auditory systems can use that system to communicate detailed threat information to their troop members, fast and over long distances. For example, vervet monkeys give different alarm calls for different predators. The recipients respond accordingly: run into trees for leopard alarms, look up for eagle alarms, and look down for snake alarms. This is a learned behavior; infants’ alarm calls are not as specific, and they improve with time (Seyfarth, 1980). In those cases, the vocal-auditory system had an evolutionary advantage over the chemo-sensory system. As humans developed vocal skills and language capabilities, they were able to more effectively communicate information that initially was communicated by pheromones. Synergy of the visual, vocal, and auditory systems, combined with a brain that can learn and process complex concepts and communicate them to large groups of conspecifics, have eroded the importance of chemical communication and the VNO. Eventually, the human VNO has become an evolutionary vestige, and its roles were taken over by the visual, auditory, and vocal systems.

Chemical, visual, auditory, and tactile signals are used by various animals in the process of selecting a mate. The use of chemical signals, on their own or in combination with other modalities, has been very common. **It is proposed that at one point of human evolution, auditory signals took over the role of chemical signals in learning and establishing the sex of the desired mate.**

EVALUATION and FUTURE STUDIES

Pre- and post-puberty learning

The model presented here deals with sexual behaviors that are learned during childhood from non-sexual experiences. The activity plans of those learned behaviors guide the initial sexual activities of the pubescent. After that, new sexual activity plans are learned from actual sexual experiences. The rewards of post puberty sexual experiences are intense, and they affect the development of new behaviors, which are elaborations of the ones that have emerged at puberty.

The roles of voice

Humans rely mainly on vision and on voice for identifying mates. Out of these two, relying on vision is more prevalent. This is in spite the fact that many of the visual cues that are used in mate identification are arbitrary and have to be learned, whereas the vocal cues are inherent and practically unmistakable. Humans can identify the sex of a person based only on his/her voice. This is true all over the world, and it has been so throughout the history of mankind.

fMRI is widely used for exploring brain areas that are involved in mate identification and arousal. PET, EEG, MEG and ERP are also used for that purpose in conjunction with fMRI or as standalone. Still pictures and videos with sexual and non-sexual contents have been presented to subjects of various sexual orientations. The roles of active brain areas and their differentiation by sex and sexual orientation were deduced by comparing and contrasting the scans (Costa, 2003; Gizewski, 2006; Jansen, 2003; Ponseti, 2006; Rupp, 2008; Stoleru, 2012).

Voice processing by the brain has also been studied by using fMRI and other imaging methods (Allen, 2017; Leaver, 2016; Pernet, 2012; Raschle, 2014; Zaske, 2017). However, reports about the relationships between voice processing loci and sexual orientation are not readily available. This is an untapped research area that could be carried out by using off-the-shelf and innovative instrumentation and techniques. Based on the spatial resolutions that have been demonstrated in studies of sexual brain centers under visual stimulations, it should be possible, using fMRI and similar techniques, to elucidate the roles of voice in mate identification and arousal. In particular, it should be possible to identify the relationships between auditory and sex control brain areas, such as the hypothalamus, and how they differentiate between the sexual orientations. It should also be possible to explore the interactions of voice centers and the amygdala and other emotion centers during sexual processes.

Such studies could test the hypothesis that sexual orientation is determined by innate connections between voice processing centers and centers that trigger the physical and emotional aspects of mate identification and arousal.

Evolutionary transitions

Although the human VNO is nonfunctional, and humans can identify mates and be aroused without relying on any chemosensory signal, PHSP create in some cases sexual-like responses,

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albeit mild ones, and they affect brain areas that are involved in sexual activities (Costa, 2003; Gizewski, 2006; Jansen, 2003; Ponseti, 2006; Rupp, 2008; Stoleru, 2012). There is evidence that the acuity to PHSP is greater in homosexuals than in heterosexuals. It has been suggested that since in the general population there are fewer possible matches for homosexuals than for heterosexuals, homosexuals need sharper mate identification tools (Lubke, 2015).

All that raises the possibility that the PHSP are vestiges of an innate chemosensory system that has been replaced by other sensory systems, but they still maintain some of their archaic functionality. It is also possible that some effects of the PHSP are learned by association, only after the sexual orientation of the individual has already been established by other means. It would be interesting to look into the responses of children to PHSP, similarly to studies of children responses to odors (Zhang, 2017).

An evolutionary transition from one sensory system to another does not require changes in the responding systems downstream. For example, if signals from the VNO for identifying a mate are replaced by voice signals, it does not require that the sex activation centers change their instructions to the sex organs. Studies may reveal that the vestiges of the chemo-sensory system and the activators from the auditory system converge together onto the same entry points of the unchanged response system. If it turns out that signals of PHSP and voice signals converge onto the same points of the hypothalamus (or onto other centers that are involved in sexual activities), that may bolster the idea that voice has replaced chemo-signaling in mate identification and arousal.

Sexual orientation of deaf people

There are no substantiated numbers derived from large populations of the prevalence of homosexuality among deaf people, especially among deaf adolescents. One report states that "…of those [deaf adolescents] who admitted sexual experience, homosexual activity was more common than heterosexual activity in adolescence – in fact, almost twice as common… Dating information was consistent with sex experience during school years but shows marked difference from the patterns of hearing peers, dating and friendships…" (Kelliher, 1973). Such observations are also common among deaf homosexual adults who feel that the proportions of deaf people within their LGBT communities are larger than their proportions within the general population. However, such observations are still at the anecdotal level (Heiman, 2015).

In deaf people, the roles of the auditory system in building the mental pictures of the world are replaced by other systems such as visual, tactile, and olfactory. In addition, larger parts of their knowledgebase is acquired by being taught rather than by being immersed in their society and absorbing what other people are talking. The inability to distinguish between men and women by their voice may impact how related concepts, including mate identification and arousal, evolve in the deaf.

It would be interesting to find out if deaf people are more sensitive than hearing people to detecting PHSP and to be affected by them. If that is the case, it may be a reversal of the

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evolutionary process in which the auditory system has taken over the role of the chemosensory system.
If it is found that gene expressions of neural pathways from auditory to sex centers correlate with sexual orientation, then that may point to the genetic loci of sexual orientation. However, if such correlations do not exist, then still, hormonal concentrations that are not expressed by genes may regulate the formation of connections between auditory and sex brain centers, and thus affect sexual orientation.

SUMMARY

The model that was described here deals with the development of sexual orientation during childhood. It illustrates how innate learning mechanisms that process arbitrary inputs can result in pre-determined outcomes. It suggests that conditioning combined with hard-wiring of certain auditory-driven circuitries that distinguish between voices of men and women determine the sexual orientation of a person that emerges at puberty. It is also proposed here that during evolution, such auditory-driven circuitries have replaced pheromone-driven circuitries for identifying sexual mates.

Sexual orientation is affected by many factors, and multi-disciplinary studies are uncovering their intricacies. The proposed model integrates numerous established observations from various disciplines. In order to integrate those findings, the model had to make some assumptions. Those assumptions could be tested using techniques such as fMRI, PET, MEG, ERP’s, genetic assays, and psychological observations. In addition, the model could also provide inroads into some open questions related to sexual orientation, such as:

Studies in which Putative Human Sex Pheromones (PHSP) and human voice are presented to the same person could reveal common converging areas of the two modalities, thus providing an explanation to the phenomena of PHSP.

Correlations between sexual orientations and genes that encode the formation of neural connections between auditory and sex activation centers could supports the basic tenet of the model about the role of voice in the development of sexual orientation.

Studies that involve deaf people could test the basic assumptions of the model, and at the same time would benefit that segment of the population that is relatively under-studied.

If verified, the model would enhance our understanding of the biological substrates of all sexual orientations.

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