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Chapter

# Evolutionary Theory of an Association between Testosterone and Attractiveness Perception in Humans

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## Abstract

Literature on psychological function of testosterone in humans has emphasized its association with such traits as aggressiveness and impulsivity. In addition, increasing number of studies have shown the linkage between testosterone level and individual difference in the strength of preference for other's sexually dimorphic traits. According to theorists in the field of evolutionary psychology, the preference pattern for sexual dimorphisms had evolved as an adaptive mechanism to increase the odds of reproductive success. But, so far, there are few systematic syntheses of literatures to validate such evolutionary explanation from the perspective of androgenic function. This chapter aims to give an overview of the existing findings on the association between testosterone and preference pattern in humans and discuss their implications for evolutionary explanation of human attractiveness perception.

**Keywords:** testosterone, preference, face, voice, evolutionary psychology

## 1. Introduction

Numerous functions of the central nervous system, perception, motor control, emotion, homeostatic balance, and so on, are discussed in the literature on psychology. The neurophysiological machinery for many of these psychological and cognitive functions has probably evolved as an adaptive mechanism—or at least as a by-product of adaptive mechanisms—to meet the demands of survival in a given environment.

The endocrinological function is tightly intertwined with neural—and hence, psychological—and cognitive functions. For example, in the cascade of fear response, the amygdala initiates a cascade process in the hypothalamic–pituitary–adrenal (HPA) axis, leading to the secretion of glucocorticoids in the adrenal gland, thereby enhancing energy consumption [1, 2]. An important implication of this is that individual differences within the endocrinological function are possibly linked to diversity in psychological traits and responses.

In addition to its physiological actions, testosterone has long been associated with psychological traits such as aggressiveness [3, 4] and impulsivity [5], especially

in males. Empirical studies using a pen-and-pencil questionnaire or well-tested paradigms of behavioral measurement have shown that people with high circulating testosterone levels tend to show more aggressive [3, 4] and dominant behavior [6]. Several earlier studies have identified a positive relationship between testosterone levels and trait impulsivity. At the same time, even when using a similar behavioral paradigm, studies have often reported mixed results as for the association between impulsivity and testosterone level, which indicates intrinsic complexity in androgenic influences on human behavior. For example, our study [7] found sex differences in the association between salivary testosterone levels and impulsivity in financial decision making, which indicates non-linearity in the pattern of influence of testosterone on a few domains of cognitive function (see also [8, 9]).

Attractiveness is among the primary attributes that determine first impressions, and attractive people make good impressions in job interviews [10, 11], receive priority in promotion [12]—possibly through a halo effect ([13, 14] but see [15])—and, importantly, in the context of this chapter, are more likely to have many sexual partners [16, 17].

In contrast to the common sense that beauty and attractiveness are defined by cultural standards, studies in the past three decades have shown the possibility that some physical traits are universally perceived to be attractive and that hormones, including testosterone, play pivotal roles in shaping attractive features and determining the strength of one's preference for them. This chapter aims to give a brief overview of the previous findings on the link between testosterone and human attractiveness perception and discuss the validity of evolutionary explanations for the observed associations.

## **2. Androgenic regulation of reproductive behavior**

Reproduction is, in a sense, the ultimate goal of living organisms—both as individuals and as members of one's own species. In addition to other hormones, testosterone and its metabolites are integrated into the complex web of the neuroendocrine system that controls the reproductive process.

Testosterone plays a pivotal role in the regulation of the male reproductive system; it controls male masculinization in body morphology and physiology [18–20] and sexual behavior [21] in variety of species. The concentration of androgen is much higher in the testes than in the bloodstream, and spermatogenesis is highly dependent on this high level of testicular testosterone [22].

There are a few controversies regarding the role of testosterone in the female reproductive process. However, at least in vitro, several studies have shown that testosterone and its metabolites promote the early stages of ovarian follicular maturation [23] directly as well as via conversion to estrogen through aromatization.

In addition to these physiological effects, several studies have shown that testosterone can modulate the function of the central nervous system, resulting in multiple aspects of reproductive behavior. Circulating testosterone levels are positively associated with male aggression, intra-sex competitiveness, and sexual desire in non-human species [21], which increases the success rate of winning and sexual intercourse with female conspecifics. In accordance with these observations, human studies have also supported the relationship between sexual desire and testosterone levels in both males [24] and females [25].

Maintaining a higher social status leads to an increased likelihood of reproductive success. Testosterone levels have been suggested to modulate the higher-order cognitive process of status seeking behavior. Eisenberger reported that men administered with testosterone make fairer offers in economic bargaining than placebo [26] and are more likely to punish those who make unfair offers [27]; both behaviors are beneficial for elevating one's social status. Likewise, exogenous testosterone administration increases generosity when the audience is observing one's behavior [28], which probably contributes to keeping good reputation.

Recent studies have shown that, in addition to its association with sexual behavior, testosterone levels modulate paternal investment. A longitudinal study [29] showed a reduction in testosterone levels in males after the delivery of their first child, similar to the findings in marmosets. Moreover, the time spent on care-taking was negatively correlated with testosterone levels. In a laboratory study [30], new fathers with low serum testosterone levels showed empathic responses more strongly to the sounds of the infant's cry. These studies indicate a suppressive effect of circulating testosterone on paternal investment.

### **3. Evolutionary theory of attractiveness**

Mainly two types of explanations can be distinguished [31, 32] for certain behaviors or behavioral tendencies observed in animals: proximate and ultimate. The first refers to the description of biological mechanisms underlying animal behavior, such as neural functions and physiological responses. In the case of attractiveness perception, viewing attractive others activates the neural network of the reward system and induces pleasure [33]. This hedonic state is considered to promote the favorable treatment of physically attractive people.

The ultimate explanation of a behavior answers such questions as what kind of adaptive benefit and costs the behavior of interest incurs and how the behavior has evolved. The possession of eye-catching ornaments in certain species, such as the long tail in peacocks, has been a puzzle for evolutionary theorists. Conspicuous tails of peacocks are almost useless in themselves and could jeopardize the survival of a peacock by making it easily detectable by predators. Why did this phenotype evolve in the first place? This question explains the evolutionary roots of sexually dimorphic traits in peacocks.

The costly signaling theory (or good-genes handicap principle) claims that possession of extravagant ornaments functions as an "honest signal" of an individual's health and reproductive prowess [34, 35]. Production and sustainment of the long tail in peacocks is energy consuming and, as mentioned above, has the potential to lower the odds of survival. This indicates that a male with a long tail is healthy and strong enough to survive despite such a large handicap. In this line of reasoning, it follows that it is an adaptive strategy for peahens in bearing offsprings with "good genes" by mating with peacocks with long tails, because a long tail is an honest signal of biological quality. Though controversial, some ethological and experimental studies obtained several pieces of supporting evidence that males with seemingly maladaptive morphological traits achieve higher reproductive success [36–38].

The role of testosterone in the perception of attractiveness is often explained based on its value of signaling. Given the association between androgen and the male reproductive function [18–22, 37, 38], morphological traits linked to high levels of testosterone can serve as a signal of high reproductivity.

Another type of testosterone signaling function has also been suggested, based on the observation that testosterone suppresses the immune response to stressors. Based on this observation, a high level of testosterone can be deemed a handicap in the survival of an organism. Thus, the immunocompetence handicap theory [39, 40] of testosterone claims that morphological traits indicative of high testosterone levels advertise high immunocompetence and higher function of the immunological system because only individuals with strong immunity can survive despite the immunosuppressive effect of testosterone.

These hypotheses claim that masculine morphological traits function as an honest signal of biological quality and fitness of an individual and thus indicate the signaling quality of these traits as an ultimate explanation of why females are attracted to masculine traits in males. Females who are attracted to masculine males mate with a high-quality male, which probably increases the odds of offspring survival. Through sexual selection, traits indicative of high androgen levels have been consolidated in male sexual dimorphism, and the female neural system has evolved to be predisposed to seek males with these traits as mating partners.

#### **4. Association between testosterone and attractiveness perception**

To evaluate the validity of these evolutionary theories of attractive phenotypes, a good starting point is the examination of existing findings on human attractiveness perception. Over the past three decades, scores of studies have been published on the characteristics of sensory signals that young adult males and females find attractive; many of these studies have dealt with the attractiveness perception of sexual dimorphism in face and voice. These studies generally indicate that certain facial and vocal traits are universally perceived as attractive. Additionally, in line with the proverb “beauty lies in the eyes of the beholder,” there is notable intra- and inter-individual differences in the strength of preference depending on the hormonal state. According to several researchers, the pattern of attractiveness perception and findings on the endocrinological basis of individual differences in attractiveness perception provide at least partial support for evolutionary theory of attractiveness perception.

##### **4.1 Faces**

The face is among the most prominent sources of social information, and the human visual system is equipped to extract various kinds of information from others' faces. When female faces are presented side by side, infants as young as two months old spend more time looking at female faces that are evaluated to be more beautiful by adults [41]. Although the ability to capture attention is an inherently different concept from attractiveness, this finding indicates that facial attractiveness may comprise a collection of low-level perceptual features that can be processed by an immature brain.

Studies of young adults have identified facial asymmetry as a strong determinant of perceived facial attractiveness. Fluctuating asymmetry is a random deviation from perfect symmetry in the body and is presumed to reflect an organism's susceptibility to stressors; thus, the lower the fluctuating asymmetry an individual exhibits, the more physically fit he/she is. Previous studies have generally agreed that a low level of fluctuating asymmetry is perceived to be attractive regardless of the face model and evaluator's sex [42, 43] (but see [44]).



Another type of morphological feature that is universally perceived as attractive is the so-called baby schema (“Kindchenschema” [45]). Infants of many species share a collection of similar morphological traits such as large eyes, round contours, and small noses. Baby schema is asserted to function as a releaser of caretaking behaviors of adult conspecifics [46]. Glocker et al. [47] showed that a computer-synthesized infant face with its “baby schema” exaggerated activates the reward region more vigorously than the original image. Attractiveness perception in baby schema is seemingly influenced by the endocrinological function. Hahn et al. [48] revealed that intra-individual fluctuation in rewarding value one finds in a baby’s face is dependent on testosterone levels. Testosterone works in concert with oxytocin to modulate the responses of infants’ faces. A behavioral study [49] revealed that nulliparous women with high testosterone levels are slower in detecting infant faces than those with low testosterone levels. However, the reaction time to infant face was accelerated by exogenous administration of oxytocin, most prominently in women with high testosterone levels.

Certain adults strongly exhibit baby schemas on their faces. Studies in the field of social psychology have revealed that people implicitly project infant-like traits such as innocence and incompetence [50, 51]. In our study [52], which investigated neural substrates linked to this over-generalization of baby schema to adult faces, part of the ventral striatum was more strongly activated to babyish than the mature version of an identical face. Part of the inter-individual variance in this activation was explained by the oxytocin level; however, in contrast to the case of infant face, testosterone was not identified as a determinant of reward system activation to faces of baby-faced adults.

In contrast to the case of low fluctuating asymmetry and baby schema that are almost universally perceived to be attractive [42, 43, 46, 52], the attractiveness perception of sexual dimorphisms in the human face is dependent on both the model’s and the rater’s sex. Sexual dimorphism refers to morphological features exaggerated in one sex. In the case of the human face, sexual dimorphisms in prototypical male faces include masculine features, such as large jawbones, protruded eyebrows, angular facial contours, and thinner lips, whereas feminine features are characterized by morphological features exaggerated in the opposite direction.

As can be intuitively understood, females with more feminine faces are perceived as more attractive than masculine ones [53] (but see [54]). If feminine features in female faces are exploited as signals of fecundity, it follows that preference for feminine faces is particularly prominent in male viewers compared to female viewers. This conjecture is supported in many studies [53, 55, 56], but some argue that there is considerable variation among males in the strength of preference for feminine female faces depending on self-perceived attractiveness and mating strategy [57, 58].

Another line of study found a positive association between circulating testosterone levels and the degree of male preference for femininity in female faces [59]. The results of correlational studies are further bolstered by the finding of a causal relationship between testosterone levels and perceived attractiveness in feminine morphological features. Welling et al. showed that winning in competition enhances male preference for female faces’ femininity [60]. Although they did not directly measure testosterone concentration, this finding hints at the possibility that testosterone level is causally linked to the attractiveness perception of female sexual dimorphism in males because winning in competition is known to result in phasic testosterone increase [61]. More direct evidence for causal linkage comes from testosterone administration studies that the administration of a testosterone patch increases preference for feminine faces [62]. At the same time, another administration study reported a

contradictory result that exogenous administration of testosterone decreases preference for femininity in female faces in a long-term relationship context [63].

The observed pattern of attractiveness perception of masculine facial features was somewhat complicated. In contrast to feminine female faces, which are judged to be attractive by both males and females alike [53], masculine male faces are not unequivocally perceived to be more attractive than less-masculine faces [64, 65]. One plausible reason for this observation is that masculine features are coupled with the impressions of dominance and untrustworthiness [53].

Sex hormones engender variations in females' perceptions of attractiveness in masculine male faces at both inter- and intra-individual levels. One correlational study has reported that females with high estradiol level show stronger preference for male faces with high testosterone [66]. A seminal study by Penton-Voak et al. [67] revealed cyclic fluctuations in the preference for masculine and feminine versions of a male face across the menstrual cycle. More specifically, during late follicular and ovulatory phase with high conception risk, females preferred masculine over feminine versions of identical male faces for partner of short-term relationship more than during the luteal phase with low conception risk. Several later studies successfully replicated this "ovulatory shift" pattern in females' perceptions of attractiveness in masculine facial features [66, 68, 69]. One interpretation of the ovulatory shift is that fluctuations in facial preference across the menstrual cycle are dependent on the mating strategy [66]. During the late follicular to ovulatory phase, females seek to find sexual partner with "good genes" to bear offspring with the greatest chance of survival, which makes them prefer masculine features. Testosterone levels are often linked to poor parental investment in fathers [29, 30]. Thus, it is a good strategy for females to mate with males with feminine morphology, from whom they can expect greater effort in parenting during the luteal phase. Partial support for the association between mating strategy and masculinity preference in females is obtained in several studies. For example, Roney et al. [70] reported that females rated male faces with high interest in children and those with high masculinity more attractive as long- and short-term partners, respectively (see also [71]). Menstrual cycle is accompanied by cyclic change in levels of multiple hormones. Consistently, several studies found a relationship between facial masculinity preference and estradiol [66] and progesterone [69] (but see [72, 73]). Testosterone level also fluctuates during menstrual cycle [74, 75]. This observation raises the possibility that facial masculinity preferences is also linked to testosterone level in females, but previous studies reported mixed findings as for this conjecture [71, 76, 77].

It should be noted that the phenomenon of cyclic shift in facial masculinity preference and its "mating strategy" interpretation are far from established in its current state. Many methodological problems have been pointed out in the studies on cyclic shift in face preference [78]. Several empirical studies reported no difference in masculinity preference between high and low conception risk phases during menstrual cycle [73] or lack of association between hormonal status and masculinity preference [72] (see [78] for a brief review). One study even reported that females preferred faces of males with relatively low level of serum testosterone during the fertile phase of menstrual cycle [79] in direct contradiction to the widespread interpretation.

## **4.2 Voices**

Prominent sexual dimorphisms in human voices become clearly observable after puberty, during which the morphology of the vocal tract undergoes maturational

changes [80] under hormonal influences [81]. Sexual dimorphism in voice expresses itself through two main aspects: fundamental frequency and formant dispersion [82, 83]. The fundamental frequency of a voice is the frequency at which the vocal fold vibrates, and its perceptual correlation is the pitch. Formant refers to the local zenith in the frequency in power distribution, where the power within specific frequency ranges is amplified by resonance in the vocal tract. The combination of formant frequencies determines the perceived vowel category.

Fundamental frequency is lower in males than in females [82]. Similarly, formant dispersion, which is the frequency distance between neighboring formants, is narrower in males [84], and spacing between formants is related to body size in macaques [85] though the relationship is relatively weak in humans [86]. Based on these observations, many experimental studies have focused on the association between these vocal features and voice impressions. As in the case of facial masculinity, voices with muscular features, low fundamental frequency, and narrow formant dispersion give an impression of dominance [87]. A male's voice with a low fundamental and formant frequency is evaluated as more attractive by females than that with a high frequency [88, 89]. Likewise, males prefer female voices with high fundamental frequency and wide formant dispersion [90]. One explanation for such pattern of preference is that acoustic characteristics of voice reflect body size and physical function of speakers; females prefer males with voice indicative of a large body size [91, 92] and physical strength [93]. A recent study [83] has identified a curvilinear relationship between perceived attractiveness and fundamental/formant frequency: overall, male voices with low fundamental frequency tended to be rated higher in attractiveness. Interestingly, this effect was particularly pronounced when female raters evaluated voice attractiveness in a short-term rather than in a long-term context, closely replicating the pattern observed in face attractiveness studies [94]. Outside of the laboratory, it has been shown that males—but not females—with a low-pitched voice succeed in bearing a greater number of children [95].

Relatively less research has been conducted on whether hormonal status modulates the attractiveness perception of sexually dimorphic traits in voices, and we are yet to obtain a coherent picture regarding this issue. A few studies found cyclic variation in masculine traits in male's voice across menstrual cycle [84, 96], especially in females with low trait estradiol level [84]. Pisanski et al. [97] have linked intra-individual fluctuation in females' preference for masculine traits in men's voice to female's salivary level of estradiol rather than progesterone or testosterone. In males, Kandrik et al. [98] failed to find any association between attractiveness perception in feminine voices and testosterone levels.

## **5. Signal value of sexual dimorphisms**

Although still equivocal, previous research has found some pieces of evidence supporting evolutionary theory of attractiveness perception. Another important aspect to be considered in validating the signaling hypothesis is whether attractive traits actually signal qualities advantageous for reproduction and offspring survival. Although this number is disproportionately small compared to purely psychological and observational studies that address the pattern and mechanism of attractiveness perception, researchers have made progress in empirically validating the signal value of attractive features.



The activational effect of androgens has been shown to contribute to cranial growth [99] and vocal apparatus maturation [80]. Consistently, previous studies have revealed an association between the expression of masculine traits and testosterone levels in facial morphology [100] and acoustic features of voice [83, 101]. However, linking muscular features and reproductive processes in males is not straightforward. Few studies have empirically investigated the relationship between reproductive function and masculine traits. A pioneering study by Soler et al. [102] reported a positive association between facial attractiveness and semen quality, as assessed by sperm motility and morphology. However, later studies failed to replicate the predicted association between semen quality, attractiveness, and masculinity in the face [103] and voice [104].

The immunocompetence handicap theory of testosterone asserts that men with high testosterone levels possess strong immune functions and thus physical health [39, 40]. Studies have tested this conjecture by investigating the association between face evaluations and actual health records [42, 105, 106]. Several pieces of supporting evidence were obtained from these studies. For example, facial masculinity and asymmetry have been linked to actual health status, indexed by antibiotic use and a history of respiratory disease [42]. However, the association between ratings of masculinity and attractiveness and actual health status was modest or absent [105]. Thus, it is possible that sexual dimorphism reflects actual health status, but people are not good at exploiting this information to its full extent, which indicates limited signaling value of sexual dimorphisms. Kalick et al. [106] observed that perceived facial attractiveness mitigated the association between perceived and actual health. More specifically, participants were good at predicting health status based on facial information for moderately attractive faces but not for extremely attractive or unattractive faces. This finding indicates that the signal value of sexual dimorphism was degraded by the halo effect of perceived attractiveness.

Another line of research has directly investigated the association between masculine traits and the strength of the immune response. A comprehensive study [107] on multiple aspects of the immune response, including both humoral and cell-mediated immunity and serum levels of free testosterone, dihydrotestosterone (DHT), and dehydroepiandrosterone, identified a positive association between the strength of the immune response to influenza vaccination and free testosterone and DHT; however, many of the pairwise correlations were null. Another study [40] investigated the association between facial attractiveness, testosterone levels, and immune response to hepatitis B vaccination. The results revealed that males with high testosterone levels showed stronger immune responses, and males with stronger immune responses were rated more attractive by females than those with weak immune responses, giving strong support to the immunocompetence handicap theory. These associations were particularly prominent in males with low glucocorticoid levels. Thus, existing studies provide some support for the immunocompetence handicap theory [39, 40] but at the same time reveal the need for further modification of this theory by integrating multiple measures of immune response and hormonal status.

## **6. Potential explanations for failure to find signal value of sexually dimorphic features**

Many attractiveness perception studies in humans rely on the assumption that attractive features function as signals of, and advertise, the biological quality of an individual to the opposite sex. This assumption has garnered some support from

behavioral studies on the human attractiveness perception of faces [46, 66–70] and voices [88–90, 93, 95]. Several of these studies show that people prefer sexually dimorphic traits indicative of high reproductivity [62, 66–70] and immunocompetence [108] and a low level of fluctuating asymmetry that reflects robustness against biological harm [42, 43]. However, it is currently difficult to assume that evolutionary theory of attractive perception has been unanimously supported by empirical studies.

There are several pieces of evidence indicating the association between sexually dimorphic traits, such as low-pitched voice, facial masculinity, and testosterone level [83, 100, 101]. However, there are few studies on the link between these masculine features, actual health records, reproductive prowess indexed by semen quality, and immunocompetence.

The reason for the lack of clear evidence for the signal value of sexual dimorphism is yet to be clarified. One reason, of course, is that the attractiveness of sexual dimorphism, including sexual dimorphism and the neural machinery to perceive sexual dimorphism as attractive, has evolved for reasons other than its signal value. The Fisherian runaway hypothesis [109] proposes that sexually dimorphic features, such as the grandiose ornament of the peacock's tail, can evolve even when they do not signal biological fitness. First, certain features emerge in one sex either as a signal of biological quality or as a result of perceptual bias. If the feature sexually attracts the opposite sex, individuals with this feature achieve greater reproductive success. Thus, this is an adaptive strategy for the other sex to mate with individuals with this feature. Through generations, the development of this feature and preference for it in individuals of the opposite sex reinforce each other in a positive feedback loop with no regard to the actual signal value. In this case, there is only loose or no association between the sexually selected feature and biological quality.

Another reason is that most existing studies have focused on the attractiveness perception of features that reflect biological fitness at the trait level, and a relatively small number of studies have dealt with the attractiveness perception of features that fluctuate within an individual depending on one's physical state [108]. The probability of bearing offspring with "good gene" depends on the mating partner's current health status as well as the baseline level of reproductivity and biological quality. Sexual dimorphism in the face and voice is a stable marker of trait-level biological quality, and current health status is more sensitively reflected in features such as skin texture [110], adiposity [108, 111], and subtle timbral features of jitter and shimmer in voice [112]. Several studies have raised the possibility that these state markers are more tightly linked to health status and exert stronger influences on attractiveness perception [108, 110, 111] and mating strategy than features reflecting unchanging trait-level biological fitness. Scott et al. [110] reported that skin coloration is prioritized over facial masculinity in the evaluation of health status and attractiveness from facial information. Likewise, Rantala et al. [108] revealed a stronger association between circulating testosterone and adiposity than between circulating testosterone and masculinity in the face and body. Furthermore, the link between facial attractiveness and the strength of the immune response to hepatitis B vaccination is mediated by adiposity and not by masculinity.

## **7. Conclusion**

Several behavioral studies have found supporting evidence for the assertion that attractive features have been sexually selected; however, this pattern is not necessarily

unequivocal. Furthermore, there is limited evidence for a link between sexually dimorphic traits and biological traits, such as immunocompetence and reproductivity. In its current state, existing studies mainly focus on attractiveness perception of phenotypes that are supposed to reflect trait-level fitness and health status. Furthermore, a few studies have incorporated the measurement of multiple hormones, failing to appreciate a potential interaction between sex steroids and other endocrinological factors influencing attractiveness perception. Moreover, as most studies have adopted a correlational design, their ability to identify the causality of the observed associations is limited. More comprehensive studies on the perception of attractiveness, incorporating experimental manipulation of sex-steroid administration, would enrich the knowledge in this field of research and provide a more solid basis to discuss the validity of the evolutionary roots of human attractiveness perception.

### **Conflict of interest**

The author declares no conflict of interest.

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## References

- [1] LeDoux JE. Emotion circuits in the brain. *Annual Review of Neuroscience*. 2000;**2000**(23):155-184
- [2] Carr JA. I'll take the low road: The evolutionary underpinnings of visually triggered fear. *Frontiers in Neuroscience*. 2015;**9**:414. DOI: 10.3389/fnins.2015.00414
- [3] Dabbs JM, Carr TS, Frady RL, Riad JK. Testosterone, crime, and misbehavior among 692 male prison inmates. *Personality and Individual Differences*. 1995;**18**(5):627-633. DOI: 10.1016/0191-8869(94)00177-T
- [4] Batrinos ML. Testosterone and aggressive behavior in man. *International Journal of Endocrinology Metabolism*. 2012;**10**(3):563-568. DOI: 10.5812/ijem.3661
- [5] Wu Y, Shen B, Liao J, Li Y, Zilioli S, Li H. Single dose testosterone administration increases impulsivity in the intertemporal choice task among healthy males. *Hormones and Behavior*. 2020;**118**:104634. DOI: 10.1016/j.yhbeh.2019.104634
- [6] Mazur A, Booth A. Testosterone and dominance in men. *Behavioral and Brain Sciences*. 1998;**21**(3):353-397. DOI: 10.1017/S0140525X98001228
- [7] Doi H, Nishitani S, Shinohara K. Sex difference in the relationship between salivary testosterone and intertemporal choice. *Hormones and Behavior*. 2015;**69**:50-58. DOI: 10.1016/j.yhbeh.2014.12.005
- [8] Doi H, Basadonne I, Venuti P, Shinohara K. Negative correlation between salivary testosterone concentration and preference for sophisticated music in males. *Personality and Individual Differences*. 2018;**125**:106-111. DOI: 10.1016/j.paid.2017.11.041
- [9] Sapienza P, Zingales L, Maestripieri D. Gender differences in financial risk aversion and career choices are affected by testosterone. *Proceedings of the National Academy of Sciences of the United States of America*. 2009;**106**(36):15268-15273. DOI: 10.1073/pnas.0907352106
- [10] Shahani-Denning C. Physical attractiveness bias in hiring: What is beautiful is good. *Hofstra Horizons*. 2003:15-18
- [11] Shahani-Denning C, Dudhat P, Tevet R, Andreoli N. Effect of physical attractiveness on selection decisions in India and the United States. *International Journal of Management*. 2010;**27**(1):37
- [12] Morrow PC, McElroy JC, Stamper BG, Wilson MA. The effects of physical attractiveness and other demographic characteristics on promotion decisions. *Journal of Management*. 1990;**16**(4):723-736. DOI: 10.1177/014920639001600405
- [13] Dion K, Berscheid E, Walster E. What is beautiful is good. *Journal of Personality and Social Psychology*. 1972;**24**(3):285-290. DOI: 10.1037/h0033731
- [14] Batres C, Shiramizu V. Examining the "attractiveness halo effect" across cultures. *Current Psychology*. 2022
- [15] Eagly AH, Ashmore RD, Makhijani MG, Longo LC. What is beautiful is good, but...: A meta-analytic review of research on the physical



- attractiveness stereotype. *Psychological Bulletin*. 1991;**110**(1):109-128.  
DOI: 10.1037/0033-2909.110.1.109
- [16] Rhodes G, Simmons LW, Peters M. Attractiveness and sexual behavior: Does attractiveness enhance mating success? *Evolution and Human Behavior*. 2005;**26**(2):186-201. DOI: 10.1016/j.evolhumbehav.2004.08.014
- [17] Karraker A, Sicinski K, Moynihan D. Your face is your fortune: Does adolescent attractiveness predict intimate relationships later in life? *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*. 2017;**72**(1):187-199. DOI: 10.1093/geronb/gbv112
- [18] Lincoln GA. Reproductive seasonality and maturation throughout the complete life-cycle in the mouflon ram (*Ovis musimon*). *Animal Reproduction Science*. 1998;**53**(1-4):87-105.  
DOI: 10.1016/s0378-4320(98)00129-8
- [19] Toledano-Díaz A, Santiago-Moreno J, Gómez-Brunet A, Pulido-Pastor A, López-Sebastián A. Horn growth related to testosterone secretion in two wild Mediterranean ruminant species: The Spanish ibex (*Capra pyrenaica hispanica*) and European mouflon (*Ovis orientalis musimon*). *Animal Reproduction Science*. 2007;**102**(3-4):300-307.  
DOI: 10.1016/j.anireprosci.2006.10.021
- [20] Malo AF, Roldan ER, Garde JJ, Soler AJ, Vicente J, Gortazar C, et al. What does testosterone do for red deer males? *Proceedings of the Biological Sciences*. 2009;**276**(1658):971-980.  
DOI: 10.1098/rspb.2008.1367
- [21] Goldey KL, van Anders SM. Sexual modulation of testosterone: Insights for humans from across species. *Adaptive Human Behavior and Physiology*. 2015;**1**:93-123
- [22] McLachlan RI, Wreford NG, Robertson DM, de Kretser DM. Hormonal control of spermatogenesis. *Trends in Endocrinology and Metabolism*. 1995;**6**(3):95-101.  
DOI: 10.1016/1043-2760(94)00215-p
- [23] Gervásio CG, Bernuci MP, Silva-de-Sá MF, Rosa-E-Silva AC. The role of androgen hormones in early follicular development. *ISRN Obstetrics Gynecology*. 2014;**2014**:818010.  
DOI: 10.1155/2014/818010
- [24] Puts DA, Pope LE, Hill AK, Cárdenas RA, Welling LL, Wheatley JR, et al. Fulfilling desire: Evidence for negative feedback between men's testosterone, sociosexual psychology, and sexual partner number. *Hormones and Behavior*. 2015;**70**:14-21.  
DOI: 10.1016/j.jyhbeh.2015.01.006
- [25] Riley A, Riley E. Controlled studies on women presenting with sexual drive disorder: I. Endocrine status. *Journal of Sex & Marital Therapy*. 2000;**26**(3):269-283. DOI: 10.1080/00926230050084669
- [26] Eisenegger C, Naef M, Snozzi R, Heinrichs M, Fehr E. Prejudice and truth about the effect of testosterone on human bargaining behaviour. *Nature*. 2010;**463**(7279):356-359. DOI: 10.1038/nature08711
- [27] Dreher JC, Dunne S, Pazderska A, Frodl T, Nolan JJ, O'Doherty JP. Testosterone causes both prosocial and antisocial status-enhancing behaviors in human males. *Proceedings of the National Academy of Sciences of the United States of America*. 2016;**113**(41):11633-11638. DOI: 10.1073/pnas.1608085113
- [28] Wu Y, Zhang Y, Ou J, Hu Y, Zilioli S. Exogenous testosterone increases the audience effect in healthy males: Evidence for the social status hypothesis.

- Proceedings of the Biological Sciences. 1931;**2020**(287):20200976. DOI: 10.1098/rspb.2020.0976
- [29] Gettler LT, McDade TW, Feranil AB, Kuzawa CW. Longitudinal evidence that fatherhood decreases testosterone in human males. Proceedings of the National Academy of Sciences of the United States of America. 2011;**108**(39):16194-16199. DOI: 10.1073/pnas.1105403108
- [30] Fleming AS, Corter C, Stallings J, Steiner M. Testosterone and prolactin are associated with emotional responses to infant cries in new fathers. *Hormones and Behavior*. 2002;**42**(4):399-413. DOI: 10.1006/hbeh.2002.1840
- [31] Mayr E. Cause and effect in biology. *Science*. 1961;**134**(3489):1501-1506. DOI: 10.1126/science.134.3489.1501
- [32] Nesse RM. Tinbergen's four questions: Two proximate, two evolutionary. *Evolution, Medicine, and Public Health*. 2018;**2019**(1):2. DOI: 10.1093/emph/eoy035
- [33] Kou H, Xie Q, Bi T. Mechanisms for the cognitive processing of attractiveness in adult and infant faces: From the evolutionary perspective. *Frontiers in Psychology*. 2020;**2020**(11):436. DOI: 10.3389/fpsyg.2020.00436
- [34] Zahavi A. The cost of honesty (further remarks on the handicap principle). *Journal of Theoretical Biology*. 1977;**67**(3):603-605. DOI: 10.1016/0022-5193(77)90061-3
- [35] Zahavi A. Mate selection-a selection for a handicap. *Journal of Theoretical Biology*. 1975;**53**(1):205-214. DOI: 10.1016/0022-5193(75)90111-3
- [36] Petrie M, Halliday T, Sanders C. Peahens prefer peacocks with elaborate trains. *Animal Behaviour*. 1991;**41**:323-331. DOI: 10.1016/S0003-3472(05)80484-1
- [37] Pryke SR, Andersson S. Experimental evidence for female choice and energetic costs of male tail elongation in red-collared widowbirds. *Biological Journal of the Linnean Society*. 2005;**86**:35-43. DOI: 10.1111/J.1095-8312.2005.00522.X
- [38] Preston BT, Stevenson IR, Lincoln GA, Monfort SL, Pilkington JG, Wilson K. Testes size, testosterone production and reproductive behaviour in a natural mammalian mating system. *The Journal of Animal Ecology*. 2012;**81**(1):296-305. DOI: 10.1111/j.1365-2656.2011.01907.x
- [39] Folstad I, Karter A. Parasites, Bright males, and the immunocompetence handicap. *The American Naturalist*. 1992;**139**(3):603-622
- [40] Rantala MJ, Moore FR, Skrinda I, Krama T, Kivleniece I, Kecko S, et al. Evidence for the stress-linked immunocompetence handicap hypothesis in humans. *Nature Communications*. 2012;**3**:694. DOI: 10.1038/ncomms1696
- [41] Langlois JH, Roggman LA, Casey RJ, Ritter JM, Rieser-Danner LA, Jenkins VY. Infant preferences for attractive faces: Rudiments of a stereotype? *Developmental Psychology*. 1987;**23**(3):363-369. DOI: 10.1037/0012-1649.23.3.363
- [42] Thornhill R, Gangestad SW. Facial sexual dimorphism, developmental stability, and susceptibility to disease in men and women. *Evolution and Human Behavior*. 2006;**27**(2):131-144
- [43] Gangestad SW, Thornhill R, Yeo RA. Facial attractiveness, developmental stability, and fluctuating asymmetry.

- Ethology & Sociobiology. 1994;**15**(2):73-85. DOI: 10.1016/0162-3095(94)90018-3
- [44] Swaddle JP, Cuthill IC. Asymmetry and human facial attractiveness: Symmetry may not always be beautiful. *Proceedings of the Biological Sciences*. 1995;**261**(1360):111-116. DOI: 10.1098/rspb.1995.0124
- [45] Lorenz K. Die angeborenen Formen möglicher Erfahrung. *Zeitschrift für Tierpsychologie*. 1943;**5**:233-519. DOI: 10.1111/j.1439-0310.1943.tb00655.x
- [46] Glocker ML, Langleben DD, Ruparel K, Loughhead JW, Gur RC, Sachser N. Baby schema in infant faces induces cuteness perception and motivation for caretaking in adults. *Ethology*. 2009;**115**(3):257-263. DOI: 10.1111/j.1439-0310.2008.01603.x
- [47] Glocker ML, Langleben DD, Ruparel K, Loughhead JW, Valdez JN, Griffin MD, et al. Baby schema modulates the brain reward system in nulliparous women. *Proceedings of the National Academy of Sciences of the United States of America*. 2009;**106**(22):9115-9119. DOI: 10.1073/pnas.0811620106
- [48] Hahn AC, DeBruine LM, Fisher CI, Jones BC. The reward value of infant facial cuteness tracks within-subject changes in women's salivary testosterone. *Hormones and Behavior*. 2015;**67**:54-59. DOI: 10.1016/j.yhbeh.2014.11.010
- [49] Holtfrerich SK, Schwarz KA, Sprenger C, Reimers L, Diekhof EK. Endogenous testosterone and exogenous oxytocin modulate attentional processing of infant faces. *PLoS One*. 2016;**11**(11):e0166617. DOI: 10.1371/journal.pone.0166617
- [50] Berry DS, Zebrowitz-McArthur L. What's in a face?: Facial maturity and the attribution of legal responsibility. *Personality and Social Psychology Bulletin*. 1988;**14**(1):23-33. DOI: 10.1177/0146167288141003
- [51] Masip J, Garrido E, Herrero C. Facial appearance and impressions of credibility: The effects of facial babyishness and age on person perception. *International Journal of Psychology*. 2004;**39**(4):276-289. DOI: 10.1080/00207590444000014
- [52] Doi H, Morikawa M, Inadomi N, Aikawa K, Uetani M, Shinohara K. Neural correlates of babyish adult face processing in men. *Neuropsychologia* 2017;**97**:9-17. DOI: 10.1016/j.neuropsychologia.2017.01.017.
- [53] Perrett DI, Lee KJ, Penton-Voak I, Rowland D, Yoshikawa S, Burt DM, et al. Effects of sexual dimorphism on facial attractiveness. *Nature*. 1998;**394**(6696):884-887. DOI: 10.1038/29772
- [54] Scott IM, Clark AP, Josephson SC, Boyette AH, Cuthill IC, Fried RL, et al. Human preferences for sexually dimorphic faces may be evolutionarily novel. *Proceedings of the National Academy of Sciences of the United States of America*. 2014;**111**(40):14388-14393. DOI: 10.1073/pnas.1409643111
- [55] Fraccaro PJ, Feinberg DR, DeBruine LM, Little AC, Watkins CD, Jones BC. Correlated male preferences for femininity in female faces and voices. *Evolutionary Psychology*. 2010;**8**(3):447-461. DOI: 10.1177/147470491000800311
- [56] O'Connor JJ, Fraccaro PJ, Pisanski K, Tigue CC, Feinberg DR. Men's preferences for women's femininity in dynamic cross-modal stimuli. *PLoS One*. 2013;**8**(7):e69531. DOI: 10.1371/journal.pone.0069531
- [57] Little AC, Jones BC, Feinberg DR, Perrett DI. Men's strategic preferences for



- femininity in female faces. *British Journal of Psychology*. 2014;**105**(3):364-381. DOI: 10.1111/bjop.12043
- [58] Burriss RP, Welling LLM, Puts DA. Men's attractiveness predicts their preference for female facial femininity when judging for short-term, but not long-term, partners. *Personality and Individual Differences*. 2011;**50**(5):542-546. DOI: 10.1016/j.paid.2010.11.022
- [59] Welling LL, Jones BC, DeBruine LM, Smith FG, Feinberg DR, Little AC, et al. Men report stronger attraction to femininity in women's faces when their testosterone levels are high. *Hormones and Behavior*. 2008;**54**(5):703-708. DOI: 10.1016/j.yhbeh.2008.07.012
- [60] Welling LLM, Persola L, Wheatley JR, Cárdenas RA, Puts DA. Competition and men's face preferences. *Personality and Individual Differences*. 2013;**54**(3):414-419
- [61] Losecaat Vermeer AB, Riečanský I, Eisenegger C. Competition, testosterone, and adult neurobehavioral plasticity. *Progress in Brain Research*. 2016;**229**:213-238. DOI: 10.1016/bs.pbr.2016.05.004
- [62] Han C, Zhang Y, Lei X, Li X, Morrison ER, Wu Y. Single dose testosterone administration increases men's facial femininity preference in a Chinese population. *Psychoneuroendocrinology*. 2020;**115**:104630. DOI: 10.1016/j.psyneuen.2020.104630
- [63] Bird BM, Welling LLM, Ortiz TL, Moreau BJP, Hansen S, Emond M, et al. Effects of exogenous testosterone and mating context on men's preferences for female facial femininity. *Hormones and Behavior*. 2016;**85**:76-85. DOI: 10.1016/j.yhbeh.2016.08.003
- [64] Scott IM, Clark AP, Boothroyd LG, Penton-Voak IS. Do men's faces really signal heritable immunocompetence? *Behavioral Ecology*. 2013;**24**(3):579-589. DOI: 10.1093/beheco/ars092
- [65] Rhodes G. The evolutionary psychology of facial beauty. *Annual Review of Psychology*. 2006;**57**:199-226. DOI: 10.1146/annurev.psych.57.102904.190208
- [66] Roney JR, Simmons ZL. Women's estradiol predicts preference for facial cues of men's testosterone. *Hormones and Behavior*. 2008;**53**(1):14-19. DOI: 10.1016/j.yhbeh.2007.09.008
- [67] Penton-Voak IS, Perrett DI, Castles DL, Kobayashi T, Burt DM, Murray LK, et al. Menstrual cycle alters face preference. *Nature*. 1999;**399**(6738):741-742. DOI: 10.1038/21557
- [68] Penton-Voak IS, Perrett DI. Female preference for male faces changes cyclically: Further evidence. *Evolution and Human Behavior*. 2000;**21**(1):39-48. DOI: 10.1016/S1090-5138(99)00033-1
- [69] Jones BC, Little AC, Boothroyd L, DeBruine LM, Feinberg DR, Smith MJ, et al. Commitment to relationships and preferences for femininity and apparent health in faces are strongest on days of the menstrual cycle when progesterone level is high. *Hormones and Behavior*. 2005;**48**(3):283-290. DOI: 10.1016/j.yhbeh.2005.03.010
- [70] Roney JR, Hanson KN, Durante KM, Maestripieri D. Reading men's faces: women's mate attractiveness judgments track men's testosterone and interest in infants. *Proceedings of the Biological Sciences*. 2006;**273**(1598):2169-2175. DOI: 10.1098/rspb.2006.3569
- [71] Marcinkowska UM, Helle S, Jones BC, Jasienska G. Does testosterone predict women's preference for



facial masculinity? PLoS One. 2019;**14**(2):e0210636. DOI: 10.1371/journal.pone.0210636

[72] Jones BC, Hahn AC, Fisher CI, Wang H, Kandrik M, Han C, et al. No compelling evidence that preferences for facial masculinity track changes in Women's hormonal status. *Psychological Science*. 2018;**29**(6):996-1005. DOI: 10.1177/0956797618760197

[73] Marcinkowska UM, Ellison PT, Galbarczyk A, Milkowska K, Pawlowski B, Thune I, et al. Lack of support for relation between woman's masculinity preference, estradiol level and mating context. *Hormones and Behavior*. 2016;**78**:1-7. DOI: 10.1016/j.yhbeh.2015.10.012

[74] Alexander GM, Sherwin BB, Bancroft J, Davidson DW. Testosterone and sexual behavior in oral contraceptive users and nonusers: A prospective study. *Hormones and Behavior*. 1990;**24**(3):388-402. DOI: 10.1016/0018-506x(90)90017-r

[75] Bloch M, Schmidt PJ, Su T-P, Tobin MB, Rubinow DR. Pituitary-adrenal hormones and testosterone across the menstrual cycle in women with premenstrual syndrome and controls. *Biological Psychiatry*. 1998;**43**(12):897-903. DOI: 10.1016/S0006-3223(98)00403-X

[76] Welling LL, Jones BC, DeBruine LM, Conway CA, Law Smith MJ, Little AC, et al. Raised salivary testosterone in women is associated with increased attraction to masculine faces. *Hormones and Behavior*. 2007;**52**(2):156-161. DOI: 10.1016/j.yhbeh.2007.01.010

[77] Bobst C, Sauter S, Foppa A, Lobmaier JS. Early follicular testosterone level predicts preference for masculinity in male faces - but not for women taking hormonal contraception.

*Psychoneuroendocrinology*. 2014;**41**:142-150. DOI: 10.1016/j.psyneuen.2013.12.012

[78] Jones BC, Hahn AC, DeBruine LM. Ovulation, sex hormones, and Women's mating psychology. *Trends in Cognitive Sciences*. 2019;**23**(1):51-62. DOI: 10.1016/j.tics.2018.10.008

[79] Krejza J, Sledziewski R, Tabedzki M, Chen R, Krzystanek E, Arkuszewski M, et al. Faces of men with high serum testosterone are less attractive for women during the fertility phase of the menstrual cycle. *bioRxiv*. 2021. DOI: 10.1101/2021.07.22.453412

[80] Fitch WT, Giedd J. Morphology and development of the human vocal tract: A study using magnetic resonance imaging. *The Journal of the Acoustical Society of America*. 1999;**106**(3 Pt 1):1511-1522. DOI: 10.1121/1.427148

[81] Newman SR, Butler J, Hammond EH, Gray SD. Preliminary report on hormone receptors in the human vocal fold. *Journal of Voice*. 2000;**14**(1):72-81. DOI: 10.1016/s0892-1997(00)80096-x

[82] Puts DA, Hill AK, Bailey DH, Walker RS, Rendall D, Wheatley JR, et al. Sexual selection on male vocal fundamental frequency in humans and other anthropoids. *Proceedings of the Biological Sciences*. 2015;**282**(1528):20152830. DOI: 10.1098/rspb.2015.2830

[83] Schild C, Aung T, Kordsmeyer TL, Cardenas RA, Puts DA, Penke L. Linking human male vocal parameters to perceptions, body morphology, strength and hormonal profiles in contexts of sexual selection. *Scientific Reports*. 2020;**10**(1):21296. DOI: 10.1038/s41598-020-77940-z

[84] Feinberg DR, Jones BC, Law Smith MJ, Moore FR, DeBruine LM,

Cornwell RE, et al. Menstrual cycle, trait estrogen level, and masculinity preferences in the human voice. *Hormones and Behavior*. 2006;**49**(2):215-222. DOI: 10.1016/j.yhbeh.2005.07.004

[85] Fitch WT. Vocal tract length and formant frequency dispersion correlate with body size in rhesus macaques. *The Journal of the Acoustical Society of America*. 1997;**102**(2 Pt 1):1213-1222. DOI: 10.1121/1.421048

[86] González J. Formant frequencies and body size of speaker: A weak relationship in adult humans. *Journal of Phonetics*. 2004;**32**:277-287

[87] Puts DA, Hodges CR, Cárdenas RA, Gaulin SJC. Men's voices as dominance signals: Vocal fundamental and formant frequencies influence dominance attributions among men. *Evolution and Human Behavior*. 2007;**28**(5):340-344

[88] Collins SA. Men's voices and women's choices. *Animal Behaviour*. 2000;**60**(6):773-780. DOI: 10.1006/anbe.2000.1523

[89] Feinberg DR, Jones BC, Little AC, Burt DM, Perrett DI. Manipulations of fundamental and formant frequencies influence the attractiveness of human male voices. *Animal Behaviour*. 2005;**69**(3):561-568. DOI: 10.1016/j.anbehav.2004.06.012

[90] Collins SA, Missing C. Vocal and visual attractiveness are related in women. *Animal Behaviour*. 2003;**65**(5):997-1004. DOI: 10.1006/anbe.2003.2123

[91] Xu Y, Lee A, Wu WL, Liu X, Birkholz P. Human vocal attractiveness as signaled by body size projection. *PLoS One*. 2013;**8**(4):e62397. DOI: 10.1371/journal.pone.0062397

[92] Bruckert L, Liénard JS, Lacroix A, Kreutzer M, Leboucher G. Women use voice parameters to assess men's characteristics. *Proceedings of the Biological Sciences*. 2006;**273**(1582):83-89. DOI: 10.1098/rspb.2005.3265

[93] Sell A, Bryant GA, Cosmides L, Tooby J, Sznycer D, von Rueden C, et al. Adaptations in humans for assessing physical strength from the voice. *Proceedings of the Biological Sciences*. 2010;**277**(1699):3509-3518. DOI: 10.1098/rspb.2010.0769

[94] Little AC, Connely J, Feinberg DR, Jones BC, Roberts SC. Human preference for masculinity differs according to context in faces, bodies, voices, and smell. *Behavioral Ecology*. 2011;**22**(4):862-868. DOI: 10.1093/beheco/arr061

[95] Apicella CL, Feinberg DR, Marlowe FW. Voice pitch predicts reproductive success in male hunter-gatherers. *Biology Letters*. 2007;**3**(6):682-684. DOI: 10.1098/rsbl.2007.0410

[96] Puts DA. Cyclic variation in women's preferences for masculine traits : Potential hormonal causes. *Human Nature*. 2006;**17**(1):114-127. DOI: 10.1007/s12110-006-1023-x

[97] Pisanski K, Hahn AC, Fisher CI, DeBruine LM, Feinberg DR, Jones BC. Changes in salivary estradiol predict changes in women's preferences for vocal masculinity. *Hormones and Behavior*. 2014;**66**(3):493-497. DOI: 10.1016/j.yhbeh.2014.07.006

[98] Kandrik M, Hahn AC, Wincenciak J, Fisher CI, Pisanski K, Feinberg DR, et al. Are Men's perceptions of sexually dimorphic vocal characteristics related to their testosterone levels? *PLoS One*. 2016;**11**(11):e0166855. DOI: 10.1371/journal.pone.0166855

- [99] Riggs BL, Khosla S, Melton LJ 3rd. Sex steroids and the construction and conservation of the adult skeleton. *Endocrine Reviews*. 2002;**23**(3):279-302. DOI: 10.1210/edrv.23.3.0465
- [100] Penton-Voak IS, Chen JY. High salivary testosterone is linked to masculine male facial appearance in humans. *Evolution and Human Behavior*. 2004;**25**(4):229-241
- [101] Dabbs JM Jr, Mallinger A. High testosterone levels predict low voice pitch among men. *Personality and Individual Differences*. 1999;**27**(4):801-804. DOI: 10.1016/S0191-8869(98)00272-4
- [102] Soler C, Núñez M, Gutiérrez R, Núñez J, Medina P, Sancho M, et al. Facial attractiveness in men provides clues to semen quality. *Evolution and Human Behavior*. 2003;**24**(3):199-207. DOI: 10.1016/S1090-5138(03)00013-8
- [103] Peters M, Rhodes G, Simmons LW. Does attractiveness in men provide clues to semen quality? *Journal of Evolutionary Biology*. 2008;**21**(2):572-579. DOI: 10.1111/j.1420-9101.2007.01477.x
- [104] Simmons LW, Peters M, Rhodes G. Low pitched voices are perceived as masculine and attractive but do they predict semen quality in men? *PLoS One*. 2011;**6**(12):e29271. DOI: 10.1371/journal.pone.0029271
- [105] Rhodes G, Chan J, Zebrowitz LA, Simmons LW. Does sexual dimorphism in human faces signal health? *Proceedings of the Biological Sciences*. 2003;**270**(Suppl 1):S93-S95. DOI: 10.1098/rsbl.2003.0023
- [106] Kalick SM, Zebrowitz LA, Langlois JH, Johnson RM. Does human facial attractiveness honestly advertise health? Longitudinal data on an evolutionary question. *Psychological Science*. 1998;**9**(1):8-13
- [107] Nowak J, Pawłowski B, Borkowska B, Augustyniak D, Drulis-Kawa Z. No evidence for the immunocompetence handicap hypothesis in male humans. *Scientific Reports*. 2018;**8**(1):7392. DOI: 10.1038/s41598-018-25694-0
- [108] Rantala MJ, Coetsee V, Moore FR, Skrinda I, Kecko S, Krama T, et al. Adiposity, compared with masculinity, serves as a more valid cue to immunocompetence in human mate choice. *Proceedings of the Biological Sciences*. 2013;**280**(1751):20122495. DOI: 10.1098/rspb.2012.2495
- [109] Fisher RA. The evolution of sexual preference. *The Eugenics Review*. 1915;**7**(3):184-192
- [110] Stephen ID, Scott IML, Coetsee V, Pound N, Perrett DI, Penton-Voak IS. Cross-cultural effects of color, but not morphological masculinity, on perceived attractiveness of men's faces. *Evolution and Human Behavior*. 2012;**33**(4):260-267
- [111] de Jager S, Coetsee N, Coetsee V. Facial adiposity, attractiveness, and health: A review. *Frontiers in Psychology*. 2018;**9**:2562. DOI: 10.3389/fpsyg.2018.02562
- [112] Asiaee M, Vahedian-Azimi A, Atashi SS, Keramatfar A, Nourbakhsh M. Voice quality evaluation in patients with COVID-19: An acoustic analysis. *Journal of Voice*. 2020;**S0892-1997**(20):30368-30364. DOI: 10.1016/j.jvoice.2020.09.024