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Approach of Evolutionary Psychology to Research of Human Sexuality and Mate Choice

Ph.D. Thesis

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Abstract

This thesis focusses on choice of partner, courtship, and stability of relationship. The emphasized phenomenon within this field are namely evolutionary origins of attractiveness and attraction, endocrine, behavioral, verbal and paraverbal displays. The courtship in this thesis is divided into three major phases – attractivity, proceptivity and receptivity – following suggestion of Beach, Freund and Money. Each of these phases is typical by certain types of behavior and reaction, such as hormonal response, vocal displays as is described in review of literature in the theoretical part. In the second, practical part, consists of four articles that address one specific phenomenon at time. The first article is focused on choice of partners in real world and their presence in sexual fantasy repertoire. The second article addresses vocal modulation when speaking to member of opposite sex who we find attractive or unattractive. The third article introduces hormonal response on possibility of gaining and loss of a potential partner in virtual courtship scenario. And finally, the fourth discusses role of female orgasm in relation to sexual and overall satisfaction in the relationship. The studies are original, and bring innovative insight to human mate-choice and courting, providing further scientific support for existence of adaptive mechanisms found in each phase of courting, and their interconnected character. All of the studies were conducted in accordance with Helsinki Declaration and good scientific manners.

Key words: Partner choice; Hormones; Attractiveness; Vocal displays; Sexuality

Abstrakt

Tato práce se zaměřuje na téma partnerského výběru, dvoření a stability partnerského vztahu. Zejména je v ní diskutováno jaké znaky jsou u člověka považovány za atraktivní z evolučního pohledu, endokrinní procesy, změna chování v rovině neverbální, verbální a paraverbální s ohledem na situaci dvoření. Dvoření je v této práci rozděleno do tří vájemně propojených celků – atraktivity, proceptivity a receptivity. Toto dělení bylo u zvířat navrženo Beachem a následně aplikováno na výzkum člověka Freundem a Moneym. Pro každou z těchto fází je typické, že se v ní vyskytují specifické formy chování, hormonální odpovědi způsob modulace hlasu. Tyto změny a projevy jsou popsány v review v teoretiké části práce. Druhá, praktická, část sestává ze čtyř článků, které jsou publikovány v impaktovaných odborných časopisech. První článek se zaměřuje na osoby – sexuální partnery – objevující se v repertoáru sexuálních fantasií a srvnává je s reálným výběrem. Druhý článek se zaměřřuje na změnu hlasového prjevu v případě, že je adresátem atraktivní a neatraktivní osoba. Třetí článek se zaměřuje na hormonální odpověď na možnost získat partnerku a její ztrátu. A čtvrtý článek adresuje vztah výskytu ženského orgasmu a spokojenosti v partnerství. Předložené studie jsou původními vědeckými články, které přináší nový pohled na výběr partnera v evoluční perspektivě a poukazují na existenci možných adaptivních mechanismů v každé fázi dvoření. Všechny části výzkumu proběhli v souladu s etikou vědecké práce.

Klíčová slova: Výběr partnera; Hormony; Atraktivita; Hlasový projev; Sexualita

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Chapter 1: Courtship and Relationship formation from Evolutionary Perspective
Pre-word

In the past times, single discipline – biology, sociology, psycholohy etc. – was applied to research of human behavior. Even to very complex behavior such as mating, and partner choice. Lately fusion of various fields is favored to uncover new important and interesting mechanisms that occur in so complex behavior that human mate choice surely is. In the following text fusion of tworelated fields of study – evolutionary psychology and sexology - combine in an attempt for new, more complex understanding of mate choice, accompanied with arguments coming from behavioral endocrinology. The evolutionary psychological approach addressing hormonal and consummatory behaviors from evolutionary point of view, explaining choices by reasons of evolutionary utility and advantageousness and implies responses within the organism on the environment (Cosmides & Tooby, 2013). Sexology researches human sexuality, sexual interests, behaviors and functioning. The commonalities are in the need for explanation of behavior, but the populations that typically are focused differ. Evolutionary psychology is mostly focused on general population, whereas in field of sexology disturbances and non-typical cases are often the in the target population of research. Based on influential article *Sexual attractivity, proceptivity and receptivity in female mammals* by Frank A. Beach (1976), founder of behavioral endocrinology, there are three phases of female courting. These three phases were later adopted by influential sexologists of their time, John Money, founder of theory of lovemaps (1986), and Kurt Freund, founder of concept of hierarchical system of courtship disorders (1986), who both re-formulated the original Beache´s system and formulated hypothesis about abnormal sexual behavior, especially based on behavioral pattern in paraphilic population. But even through there are many implications for general population, the hierarchical system dividing phases of courtship attractivity, proceptivity and repecptivity (Beach, 1976) is rarely employed for explanation of general mechanisms of mate-choice and courting within.

The first chapter will therefore be dedicated to introduction of the relevant theoretical backgrounds of both fields – the Evolutionary Psychology, and Sexology. In the latter parts, the three phases of courting will be described on behavioral level, and endocrine processes will be addressed from perspective of both sexes, where the original articles are described within the context of other findings in the field of above mentioned research scopes. In the

following chapters composed of four original research papers submitted to or printed in scientific journals. Namely chapter 8th addressing the sex differences of choice of a partner on behavioral level as well as on level of sexual imagery - *Sex differences in the incidence of sexual fantasies focused on evolutionary relevant objects*, which represents the phase of attractivity, but has further implications for all phases of courting. The next chapter is devoted to modulation of a voice - *Vocal modulation during courtship increases proceptivity even in naive listeners,* which falls in the phase of proceptivity. The 10th chapter is devoted to hormonal response on possibility of gaining and loss of the partner –*Young-Adult Men React with Changes in both Testosterone and Cortisol Levels during virtual within-group Competition for a Desired Partner*which also falls in the phase of proceptivity. Finally, 11th chapter that is devoted to role of sexual functioning and partnership satisfaction - *Sexual satisfaction, sexual compatibility, and relationship adjustment in couples: the role of sexual behaviors, orgasm and men's discernment of women's intercourse orgasm*, which falls in phase of receptivity. The studies are original, and bring innovative insight to human mate-choice and courting, providing further scientific support for existence of possibly adaptive mechanisms found in each phase of courting, and their interconnected character. All of the studies were conducted in accordance with Helsinki Declaration and good scientific manners.

1. *Evolutionary Psychology*

In the past decades, there has been number of researches that have focused on topic of cooperation, competition, partner choice, mate selection. Various approaches were used to prove or disapprove existence of mechanisms that are responsible for such phenomenon as antagonistic interactions, rivalry, but also attractiveness, sexual interest, and pair bonding, during interaction with other individuals, that were for their adaptive value affected by selection, and there may exist domain-specific psychological mechanisms that address these problems (Tooby & Cosmides, 1992, Symons, 1979), these mechanisms were shaped by natural selection over past periods of time to solve the recurrent problems faced by our ancestors (Buss, 1995).

It is typical for evolutionary psychology to explain the behavior or reaction to certain situation by means of evolution, and therefore being adaptive in an ancestral environment which may contrast with the ideal reaction of an individual or group in the current environment

(Cosmides & Tooby, 2012). As an example, *fight or flight* reaction can be mentioned. This reaction described by Cannon (1932) is a complex physiological and behavioral response that protects an individual from possible danger and harm. In the situation of threat (also social), the organism on low level initiates the freeze response (absence of movement, often accompanied by decrease of physiological functions), if the thread continues, flight response is initiated but if the perception of the situation is that no flight is possible, the reactive aggression is initiated. It is connected with change of bodily functions due to massive amount of catecholamines introduced in the system, further followed by steroid hormones testosterone and cortisol that modulate not only physiological but also psychological state of the individual (Shulkin, 2003). Such repetitive and evolutionary relevant encounters have direct impact on the social behavior towards others such as cooperation, aggression, and mate choice since all of these are occupied by automatic decision making (Blair, 2001). Therefore, it is important to stress that also the hormonal reaction to a social situation is product of evolution and in specific cases falls in to field of evolutionary psychology (Roney, 2009), constituting a hormonal and behavioral adaptation.

1.1 Partner Choice in Evolutionary Perspective

Darwin postulated that there are two main pressures on partner choice – the competition within one sex and competition between the two sexes (Darwin, 1859). In his famous book *On the Origins of Species by Means of Natural Selection* he stated that (p. 916) "The sexual struggle is of two kinds; in the one it is between individuals of same sex, generally the males, in order to drive away or kill their rivals, the females remaining passive, whereas in the other, the struggle is likewise between the individuals of the same sex, generally the females, which no longer remain passive, but select the more agreeable partners". Even though, today we know that even women compete between themselves and female-female competition is present. The competition is not physical as is usual in men but rather gossiping and indirect insults are employed as result of different social and physical abilities and capabilities (Buunk & Fischer, 2009). Many researches support claim that women mainly compete by looks and overall attractiveness (Buss & Dedden 1990) but the aim is the same – to dismiss all rivals by self-promotion and competitor derogation which pays to men and women (Schmitt & Buss 1996).

There is important point to note that there is difference between male and female investment in their offspring. The primary difference is in possible amount of offspring that each sex is able to produce. The number of offspring that men are theoretically able to produce is disproportionally greater than the women can (Trivers, 1972). The difference is caused by three means, namely (1) by different energetic investment in gametes - female ovum and male spermatozoon differ in size. But also (2) by energetic investment in development of an offspring due to intra-body fertilization. Followed by (3) breastfeeding after the offspring is born (Grafen, 1991) which impacts strategies that are used in choice of the partner. This of course leads to different mating strategies in men and women. In exaggerated terms we could say that men are investing in quantity, thus producing large amount of gametes, and benefit from larger quantity of female partners (Trivers, 1972). Male sexual behavior focused on quantity could possibly lead to fertilization of large amount of women, making his fitness increase tremendously, whereas women by the same strategy would not gain and rather prefer quality in their mates (Binter *et al.*, 2012). [This article is part of the original papers that constitute part of this thesis] Conversely, by being choosy about their partners, women can increase their fitness due to choice of a mate of high quality (Kaplan & Lancaster, 2003). Though in their long-term partners the vision of marriage and offspring is an important factor in both sexes, short term strategy is also present in both sexes (Stewart *et al.*, 2000). Women could benefit from short-term strategy by obtaining high quality gametes by having sex with someone who will not latter invest in the offspring. This hypothesis was supported by study of Sheib (2001), who asked participants evaluation of traits that covered character traits as well as physical traits of potential partners. The finding clearly supports good gene hypothesis since in short-term mate's physical attractiveness was the key component for decision in both sexes. In study of Steward at al. (2000), the income – resource acquisition – was the decision factor when women were rating men. The situation in which such decision-making occurs is also an important factor. The author suggests that being in a steady relationship *and* having an affair with the "good-gene" male would be ideal scenario for short-term strategy in women so resources could be obtained from the primary partner but good genes – the fertilization – from the high quality short-term mate. To compare the two sexes in prevalence, study of Schmidt *et al.* (2001) compared three variables that are typical for short -term-maters – greater desire for short-term mating, large number of sexual partners, and shorter time before consenting to sex. In all above mentioned cases men significantly outscored women, hence the behaviors were still present also in women.

There are clear benefits of short-term strategies for men – low investment in mates and increasing number of offspring. In short-term mates, according to study of Steward at al. (2000) men do change their preferences compared to case when long-term partners are favored. Men evaluating short-term partners even more value physical looks in women. This is further supported by study of Regan *et al*. (2008) that found high importance of attractiveness and sexual desirability in short-term partners by men.

Also study of Binter *et al*. (2012) which used a purpose oriented questionnaire that mapped presence of sexual fantasies but also actual sexual behaviors, with ten evolutionary relevant objects, chosen based on evolutionary-psychological literature. Each of the objects, present in the list, represented ideal sexual strategy of one or both of the sexes. The result supports evolutionary psychology expectations for each sex. [This article is part of the original papers that constitute part of this thesis]

2. *Phases of Courtship*

Evolutionary sexology, which combines more fields of scientific research such as biology, medicine, psychology, and focusses on people's sexual interests, behaviors, and also stresses research in the abnormal population such as sexual aggressors, pedophiles etc. and as result of studying their abnormal behaviors deduces etiologies of unusual sexual practices and preferences. This approach, in one of its branches, emphasizes existence of relatively rigid set of sequences that occur during the initial part of the relationshipformation. There are three authors crucial for this approach which emphasizes the behavioral steps preceding formation of a dyad: F. Beach, J. Money and K. Freund. Behavioral endocrinologist Frank A. Beach (1976), defined three phases of formation of pair, as a sequence of attractivity, proceptivity and receptivity. Since Beach was a primatologist, his model relied on non-human cases in the interaction primarily but has been adopted soon after to research of humans as well. The first part of the sequence is *attractivity*, during which females display their immediate reproductive status namely by olfactory and visual signals (positioning, behavior) and its aim is to attract the attention of males. The second phase*, proceptivity* is characterized by appetitive responses by female to stimuli received by males, who reacted to her presence, thus suggesting more direct interaction and enhancing the interaction. Since Beach is founder of behavioral

endocrinology it is important to mention here, that hormonal reaction of both sexes are expected, but this topic will be discussed later. *Receptive phase (receptivity)* is defined by consumatory behavior – copulation.

His approach was later adopted by other scientists, most influentially by Kurt Freund and John Money. Hence it is important to say, that contrary to Beach, who addressed mainly female behavioral sequence, the two latter authors address both sexes in their theories. Kurt Freund´s conception of Sexual Motivational System (Freund & Blanchard, 1986) was used in research of sexual paraphilia, namely pedophilia and aggressive sexual behavior. It includes the same four phases, dividing the phase of proceptivity into two, due to differentiation of intensity (mainly of touch), otherwise they match Money´s, respectively Beache´s ones, and it is not uncommon to find the theories mixed in latter scientific literature for sake of similarities and commonalities in description of multiple stages. Those should occur, according to Freund´s theory, which for dividing the second phase in two will be emphasized in further text, in the prescribed order: (a) location and first appraisal of a potential partner; (b) pretactile interaction, which may consist of looking, smiling, posturing, or talking to a prospective partner; (c) tactile interaction which consists of short or prolonged touches, holding hands, full body rubbing; (d) effecting genital union which consists of various sexual practices, originally solely of penile-vaginal penetration but lately also oral sex, anal sex and other highly intimate behaviors should be included(Freund & Blanchard, 1986) Freund´s theory also describes faulty transitions between each phase. This was important since Freund and Money were cliniciansand their research mainly focused on sexual abnormalities. John Money developed, probably independently, but also under influence of Beach, concept of *lovemaps*. Money developed the theory for reasons of sexual diagnostics and treatment Money describes lovemap as: "a developmental representation or template in the mind and in the brain depicting the idealized lover and the idealized program of sexual and erotic activity projected in imagery or actually engaged in with that lover" (Money, 1986, p 290). In his article *Evolutionary Sexology: the hypotheses of song end sex* he states that there is *courtship ritual* "occurring between men and women that has been programmed in the human brain in form of robot-like program" (p.399). All of the authors devoted some part of their work to homosexuality, which both understood as non-clinical, if voluntary, but in the further text mainly heterosexual, pair formation in non-clinical population will be discussed.

Although the concepts have been criticized for inconsistency with other fields of science, and therapeutic impacts (not part of the thesis, for further reading see e.g. Berenger *et al.*, 1988,

Downing, 2010) the concept of pair-bonding and formation of relationship occurring in interconnected stages is still plausible and fully functional as a model. In the future research the existence of interconnected phases can be further supported despite the fact the authors do not mention it directly. Moore (1985), Grammer (1998), (Grammer, 1990) for review see Moore (2010), who did not address hierarchically ordered stages in their original articles but their findings suggest different behaviors in the initial phase, before actual verbal contact occurs, in the phase before the two counterparts start to touch each other and after the touching is present, matching the Freund´s model of four stages. Authors such as Weerth & Kalma (1995) identified two stages: *contact and self-presentation*, that match the attractivity and proceptivity phase, the phase of receptivity is not described but the article addressed it as part of future pair formation. Also Brak-Lamy (2015) found six phases (seven including sexual intercourse): *nonverbal seduction, visual seduction, verbal seduction, and acting —consisting of caresses, touches, kisses, and sex,* that can easily be divided in the four Freund´s stages. In the following text, each of the original Beache´s phases will be discussed, having in mind that that in real-life scenarios the stages rather occur as continuum with an overlap. As all above mentioned authors only address a possibility that the two people meet for the first time, and during this initial interaction only certain behaviors occur, it is important to point out that namely the pretactile and tactile phases may alter when repeated exposures occur. The phases will be separately discussed from several points of view. Namely behavioral, and hormonal reactions will be emphasized since complex behaviors and reactions, some of which can be understood as adaptations, signals and cues, in each phase can be expected. In the following text adaptation will be understood as mechanisms and behavioral strategies that have evolved as solution to specific problems encountered during evolutionary history problems (Buss, 1999). According to signaling theory (Scott-Philips, 2008) there are signals and cues. Signals are defined as "any act or structure that (i) affects the behavior of other organisms; (ii) evolved because of those effects; and (iii) which is effective because the effect (the response) has evolved to be affected by the act or structure" (Philips& Pitton, 2008, p. 387). Cues are defined as "any act or structure that (i) affects the behavior of other organisms; and (ii) which is effective because the effect has evolved to be affected by the act or structure; but which (iii) did not evolve because of those effects" (Philips & Pitton, 2008, p. 387). It is important to say that in case of the researched topic– human courtship – the two are rather undistinguishable. It is rather unsolved to which degree non-verbal or paraverbal behavior, and its components are *evolved* to cause certain effects in the recepient and also to which degree they may be manipulated or hidden consciously. The unconscious display is such a cue that is under no

control (or very low control) of the sender of the signal or cue. Typical example can be blushing related to shines during interaction with desired communication partner (Crissey & Parish, 1993). Somewhere in between conscious and unconscious falls nonverbal (including para-verbal) communication due to fact that it may be controlled by will but during communication people often forget to regulate it (Caleys & Cauberghe, 2014), or cannot regulate it by will in all cases (Ekman &Sulivan, 2006). Self-manipulation (such as playing with hair, adjusting clothes for no reason) seems to be one of classical examples of unconscious non-verbal displays signaling interest (Grammer, 1990). Conscious signals, on the other hand can be used to direct the conversation in desired direction and various verbal, para-verbal, and non-verbal displays may be used to achieve the goal. As examples of verbal conscious displays, metaphor, metonymy, and hyperbole in language can be given, but since this is rather broad topic, deeply affected by culture, it will not be further discussed (for further reading see Goossens, 2002, and McCarthy & Carter, 2004). For case of para-verbal and non-verbal communication it is much more complicated to tell if chosen actions fall in category of voluntary or involuntary, is or is not adaptation, and it is highly probable that there are more categories present at one moment. This phenomenon – presence of conscious and unconscious signals – can be best studied in case of deception and lying which both may occur during courting as was shown by Roney *et al*., (2003). Roney found that men "adjust" themselves to match the preference of female that they desire.

During lying and deception, the individual is forced to have all involuntary movements and gestures under control to confuse the recipient of the message. This is discussed in the review article by Ekman & Sulivan (2006) where the authors analyzed role of gestures, facial expressions, involuntary movements but also vocal displays in liars. They found mismatch in the following domains: morphology – the appearance of the display is unnatural, timing – the duration and onset of the display is present more, less or too soon, too late or present for too short or too long time period, symmetry – namely facial emotions seem to be symmetric if deliberate, and cohesion – the display seems to occur out of proportion, and the above described mismatches combine on more levels.

3. *Phase of Attractivity*

Beach in his article states that visual cues, that females use to attract potentialmates´ attention are visual, olfactory, vocal and behavioral displays. In the non-human literature, we can find strong support for such cuing, mainly present in seasonally mating species. The most notable are female swellings inchimpanzees, which signalize fertility, and are dependent on the level of estrogen (Emeri & Whitten, 2003).It is typical for the phase of attractivity that the two, or more, individuals are distant from each other, do not interact directly and have not met before, since such interactions do follow different rules and assumptions. The distance between the two, affected by the environment, can be expected to range between two and twenty-five meters. The lower limit can be deduced from literature related to personal space (Schiffenbauer & Schiavo, 1976), and the upper limit is based on the fact that the facial expressions and saddle change of posture has to be perceived with no distortion (Sussman& Hollander, 2014)

3.1. *Appearance*

In evolutionary-psychological literature we will find that one of the important qualities of the desired partner are looks. The reason why these are valued was hypothesized by Zahavi (1975) who called them honest signals (in literature also called *zahavian* for obvious reason). Zahavi hypothesized that when the quality is desired, living organisms would "cheat" on each other and signaled it even when no qualities are present, unless the signal is too costly and its production is not available to those who, to use economical terms, cannot afford it. In men, traits that are related to higher testosterone levels, which is considered immunosuppressive (Folstad & Karter, 1992) and the expressed traits zahavian signals, are preferred by women (Perret *et al*., 1998). Male facial attractiveness is connected with lateral symmetry, large jaw, prominent brows – typical sign of increased levels of testosterone (Penton – Voak, 2001), tested on photograph ratings, and *V-shape* of the upper body connected with higher muscularity (Swami & Trovée, 2005). One of the traits that are common to men and women is lateral symmetry. Lateral symmetry is suggested to be dependent on developmental and genetic quality of the individual (Jones *et al*., 2001). This has been tested on facial

photographs of men and women (Rikowski & Grammer, 1999), and on photographs of a body (Geary, Vigil, & Byrd-Craven, 2004). In general, women prefer men, who seem to exhibit sex-typical traits, and health, but the preferences may shift as is discussed in section devoted to hormones. Since resource acquisition and socio-economic status, and prestige are also highly valued by women in men, displays of higher position can be used by men to attract women (Pawlowski & Koziel, 2002). Typical examples of such displays are clothes, Townsend & Levy (1990), this has been researched by presenting women with photographs picturing more and less attractive male models wearing suit or fast-food uniform, expectedly attractiveness of the model for a date was much lower if dressed in a uniform suggesting low income. Also being pictured in more expensive cars increase male attractiveness to women (Dunn & Swarle, 2010).

In women, men do prefer features related to higher estrogen levels (Thornhill & Grammer, 1999). Namely a smaller chin, higher cheekbones, and full lips are rated as attractive by men in the face (Rhodes, 2006), which is tested on composites of photographs. Female bodies are rated as highly attractive when ratio of waist to hips is 0.7 (Singh, 1993) suggesting appropriate fat distribution related to fertility and health, and body mass index (weight in kilograms divided by height in meters square) is close to 18 $kg/m^{2,}$ suggesting relatively low body fat (Tovée *et al*., 1999). In general, men prefer in women traits thatsignal youth, health and genetic quality. For review of male and female physical attractiveness see e.g., Weeden & Sabini (2005). Women also use various ornaments to compete with other women by looks, especially by wearing specific clothes that show more skin, are of red color, etc., which is further discussed in part devoted to hormones, since there is clear link between phase of menstrual cycle and dressing in women. The above mentioned traits will be preferred in partners of opposite-sex, and will be part of the evaluation process.

3.2.   *Behavioral Patternsin Phase of Attractivity*

Generally, in phase of attractivity the looks (as suggested above) are rather primary information for the opposite sex, and set of behavioral patterns is rather scarce compared to proceptive stage. On the other hand, it can be assumed that choosing the right location, namely public places (Haselton & Gangestad, 2006), occupied by other singles, where the meeting of people interested in dating is generally expected and appropriate (Brak - Lamy,

2015). Also placing oneself in the room, or other location, where the individual can be seen and can observe others may be considered at least of same importance as other types of displays in this phase (Moore, 1985).

As for actual behaviors, Guéguen (2012a) and Moore (1985), for example found that in front of men, women walk slower, to exhibit their body. As for behavioral displays, that are present in the female, it has been namely addressed by Moore (1985), who conducted a study on random female subjects on university campus.The most frequent non-verbal signal present in women in this study was the room- or group-encompassing glance, which had no particular recipient, also head toss, hair flip and neck presentation, also application of lip-stick, especially in the prolonged manner, self-manipulation, namely of clothes, indirectly was also suggested making of sound to attract attention, and "being in a tight situation" which would need assistance from bystanders (Moore, 1985). The last two mentioned may be understood as rather fast transition to phase of proceptivity. Generally, women seem to attract the attention to upper body and head but also to secondary sexual characteristics – breasts and hips. What is more important, the females exhibiting such behaviors were able to attract attention of potential mates and were approached in higher rate, than other women. In comparison to women, men seem to be rather passive, which strongly contrasts with the following phase, and exhibit very few behaviors that in all cases are related to dominance, and displaying of high social status (Renninger, *et al*., 2004, Grammer, 1990) such as taking more space, and intersexual touching. Two displays, category of which is debatable, and can be understood as borderline between phase of attractivity and proceptivity, are body position and smile. Although they suggest interaction, which should, in the original concept, not be present in the attractivity phase, the empirical evidence suggests (Moore, 1985, Renninger *et al*., 2004, Grammer, 1990) that the smile, even in very brief form, is present very soon. This may have two explanations, first, the "no danger from me" signal, which especially men can display to decrease fear from misbehavior before they decide to approach. The second, "I like you more than others" signal that may come from women to increase chance that the man, who the signal is directed to will speed up in his decisions to approach her before others. This could be connected with orientation of the body towards the more desired men by women, and men may do the same to make sure they capture that the woman directs more interest, e.g., brief smiles, to them. The smile and change of orientation of the body may happen at some point, then relatively long pause may occur (not mentioned in the literature), or can be followed by approach typically by men (transitional option), as suggested further.

3.3.   Role of Hormones in Phase of Attractivity

Women, as opposed to primates and other vertebrates, supposedly do not mate seasonally (even through there has been several suggestions for seasonal mating, but that is mainly found in non-western societies dependent on resource acquisition abilities in different seasons, Bailey *et al.*, 1992), and it has been suggested by Symons (1979) that the female ovulation is concealed – it is not possible to distinguish fertile and non-fertile phase in women. This hypothesis was challenged by number of studies addressing the change of e.g., facial attractiveness (Puts *et al.*, 2013), which is rated as higher closer to the follicular phase. Whether concealed ovulation is existent, or not is not clear by now, and further research is needed, and the theory has been criticized (e.g., hypothesis of perceptual spandrel was suggested by Havlicek *et al.*, 2015), for further reading see Pawlowski (2016). Hormonal dependent change in the body looks, women change the way they behave – the way they walk does change with phase of the menstrual cycle – is more attractive during the fertile phase (Fink *et al.*, 2012), make-up use is enhancing the attraction, namely women use more makeup in near ovulation phase (Guéguen, 2012b), and women dress differently (Haselton *et al.*, 2006). Kirkendal (1961) showed that women intentionally use dress and makeup to gain more attention from men, and men are aware of this and seek for such displays as shown by Brak - Lamy (2015). Not only is the follicular phase, connected with higher levels of ovarian hormones, connected with change in behavior and dressing, that attracts more attention of men but also, near ovulation phaseis also typical by increased interest in masculine physical traits in men: faces (Penton-Voak *et al*, 1999), voices (Puts, 2005), and bodies (Little *et al.*, 2007, for further reading see e.g., Penton-Voak & Perrett, 2000, Gangestad *et al.*, 2002, Jones *et al.*, 2008, Roney & Simmons, 2007, for review see Benedict *et al.* (2008).

Women also show higher interest in going to social gatherings (such as dance clubs) where they can be seen and met by men (Haselton & Gangestad, 2006), hence it is important to say that this study was conducted on paired women, but similar tendencies may be assumed in unpaired ones.In the same time – late follicular phase – there is tendency in women to change the appearance the way that more attention is aimed at them, tendency to go out in public, and with increase of ovarian hormones, stronger preference for traits related to higher androgen-related features in men (Roney, 2009).

In men, of course no cyclic changes can be expected but interestingly their dating status is impacting their level of testosterone (biologically active 5α-dihydrotestosterone, usually measured from saliva) – single men seem to have approximately 20% higher level of testosterone (Roney *et al*., 2003). There are adaptivereasons for this change, first is energetic – it is rather costly to maintain high testosterone level since it is immunosuppressive. Secondly, it is unreasonable to maintain high testosterone, connected with risk taking behavior such as fights with other men, and interestin women (Roney, 2009) which is beneficial namely for single men. Indeed, it has been suggested that there is certain amount of testosterone present in the organism to facilitate the functions dependent on the basal level, and the change of the level of testosterone (Archer, 2004). Promiscuous men do have higher levels of testosterone than paired and single non-promiscuous men (Roney, 2009), but the causality is rather unclear. Basal level of testosterone is also related to tendencies for dominant psychological traits (Booth *et al*., 1989, Archer, 2004), and aggressive behavior (Archer, 2006), which comes especially handy when unpaired, since other single men are primary competitors, and physical as well as psychological dominance, connected with risk taking, may be advantageous. This can be supported by research of Roney & von Hippel (2010), who conducted a study on skateboarders who performed tricks in front of male and attractive female confederate. The presence of an attractive female confederate caused increase of testosterone level as well as increase in risk taking (performing more complicated tricks). Even though it has been addressed by Roney (2009), there is no research suggesting that increased testosterone would affect preference for higher ovarian hormone related features in women. But generally higher testosterone in men is related to higher sexual desire (Mazur & Booth, 1998; Archer, 2006), higher self-esteem (Putz, 2004), and consequently increased number of sexual partners (Peters *et al*., 2008).

In women, although present in much lower dose than in men, testosterone is predictor of their sexual desire, and sexual strategy. Women whose testosterone levels are higher were found to have less restricted sexual behavior and more sexual partners (Davis & Tran, 2001).

3.4.   *Attractiveness of Vocal Displays*

Also partly dependent on hormonal levels in both sexes are vocal displays. Since in this stage no verbal communication is present, only paraverbal displays, such as low fundamental frequency - perceived depth of voice - will be discussed. Fundamental frequency (F_0) is

dependent on testosterone level in men. The higher is the testosterone level, the deeper is man´s voice (Puts *et al*, 2006). This seems to be linked to thickness of vocal folds but also to body size which is also impacted by testosterone levels (Puts *et al*., 2006). F_0 seems to also be sexually selected trait, in men, since the difference of body size between men and women does not account for the difference between male and female F_0. Male voices are much deeper than the body size would suggest, and hypothesis of Puts *et al*., (2011) suggests that F_0 is related to dominance and can be used as a ritualized competition. Indeed, men rate other male voices as more dominant when deeper. Furthermore, it has been found, that women find the deeper voices in men more attractive, and men who do have deeper voices do have more partners in course of their lifetime (Puts *et al*., 2007). There are also other parameters such as timbre, but these seem to not have stable impact on attractiveness of vocal displays. Formant dispersion (D_f) has also be found to contribute to perception of male voice as being dominant but since the article of (Puts *et al*., 2007) has used manipulated vocal displays, and F_0 and D_f change together when manipulated, the exact role of D_f is yet to be uncovered.

In women, the opposite is true, and higher F_0 is associated with higher attractiveness on an optimal level, too high voice is not attractive which authors believe is sign of sexual immaturity (Borkowka & Pawlowski, 2011). Vocal pitch in women has been found to be impacted by levels of two hormones, estrogen and progesterone, and female voice is changing during the menstrual cycle according to the phases when hormone levels change (Feinberg *et al*., 2006). It has also been found that F_0 in women can be related to perceived dominance, the deeper the voice was the more dominant but less attractive the voice has been found (Borkowka & Pawlowski, 2011).

4. *Phase of Proceptivity*

During the transition, behaviors usually attributed to one stage may occur in the other. In the phase described as proceptivity Beach describes the interaction as initiated by both parties: "proceptive behavior consists of appetitive activities shown by females in response to stimuli received from males." (Beach, 1976, p 114). This phase is used by women to evaluate, if the opposite sex partner would fit her criteria for becoming a mate or a lover. Interestingly, the original theories of do not address the future purpose of the courtship behavior directly, and

neither does any mentioned literature whether the courtship should lead to sexual intercourse, long term relationship development, or other kind of interaction. The important questions then is, if the individual is aware of the aim, and if that impacts their displays. It also is possible that only one of the two communication partners is aware of their goal, whereas the other is not. During the phase of proceptivity the distance between the two interacting individuals can be expected to be between two meters and can decrease to full body contact (Weerth & Kalma, 1995, Moore, 1995).Unsurprisingly if the interaction is pleasant, the two individuals decrease the distance between each other and vice versa due to effect of intensification – the pleasant is more pleasant in short distance and more unpleasant is more unpleasant in short distance range (Schiffenbauer&Schiavo, 1976).

4.1. Initiation of the Contact and Activity during Courting

Different looks of women, attracting the attention of a men has already occurred in the previous phase. Also it is important to say, that all the previous authors (Money, 1986, but especially Beach, 1976) see more activity being dependent on the women in the very initial phase, but then the men is the active agent, in the following ones, which may in Money´s case be explained by the primary nature of his research that has been conducted on and results aimed for individuals whose sexuality is distorted which is more prevalent in men. Freund, to my understanding, puts the two sexes more on a level, or at least by predicting the two stages within proceptivity – pre-tactile and tactile (Freund & Blanchard, 1986). During the beginning of the tactile phase the female is more in control since it is her who initiates the touch, the activity seems to on her (but that is solely deduced from later literature, the topic is not directly discussed in Freund´s original work).Brak - Lamy (2015), who also found set of stages that occur in a sequence, namely: nonverbal seduction, visual seduction, verbal seduction, and acting —consisting of caresses, touches, kisses, sex, found that each sex is more initiative in different domain – verbal in men, non-verbal in women, which may cause bias in judging activity.

This, in combination with fact that some women in his sample intentionally went to clubs to find a partner for sex that night, and used specific strategies to do so, puts the activity in hands of the "goal oriented one" more than it makes male or female domain to be active or passive. Grammer (1990) addressed this and stated that the female intention should not be obvious.

Also women are choosier in selecting their partners (Trivers, 1972, Barett, 2007, Grammer, 1990, Moore, 1985, Moore, 1995, Binter *et al*., 2012), and need time to evaluate them, whereas men, due to low investment can aim on having more promiscuous and risky sexual behaviors. To demonstrate an exaggerated example, in review article of Clark & Hatfield (1989) discussing result of two classical studies (Clark & Hatfield, 1989). In both of the studies the male and the female confederates, of average looks, asked opposite-sex potential partners on campus three questions: "Would you go out tonight?", "Will you come over to my apartment?", and "Would you go to bed with me?". Unsurprisingly, the result was that men, more likely than women, agreed to casual sex offer (75%, 69% respectively), compared to 0% of women accepting the invitation. In case of invitation to the apartment men also outscored women (69% of men agreed in both studies, and 6% of women in 1979, and 0% in 1982). In case of invitation for a date, the two sexes were relatively equal (56% of women accepted compared to 50% of men in 1979 study, and 50% men and women in study from 1982). Also, negative answers to the offer were collected. Typical male reaction when they refused was related to existence of other relationship "I am going with someone", or plans "I cannot tonight, but tomorrow would be fine" (Clark & Hatfield, 1989, p 52), and was apologetic. Whereas female reactions were angry and dismissing "You've got to be kidding" or "What is wrong with you? Leave me alone." (Clark & Hatfield, 1989, p 52). This has been best addressed by Weerth & Kalma (1995, p 719):

1. Females seem to be aware of their own subtle nonverbal solicitations and males seem to believe that their overt approach is the real initiation. Therefore, both males and females think that they themselves are more often the initiators of contact-seeking behavior in courtship contexts with unknown individuals of the opposite gender.
2. Males are more likely than females to admit that they would try to court an unknown subject of the opposite gender.
3. Males think that they, and not the females, should be the ones to initiate contact in courtship context with unknown females.
4. Males will indicate using more direct, verbal tactics when intending to initiate romantic contact, while females will report using more indirect, nonverbal behaviors
5. When presenting themselves during first encounters with a potential partner, there will be differences in the personal characteristics that males and females stress. These characteristics will be due to dissimilar gender expectations, but they will not be many

and will not correspond to stereotyped gender roles. Instead, males will underline expressive, 'female-valued' characteristics, while females will stress instrumental, 'male-valued' personal traits.

4.2. Behavioral Patterns in Phase of Proceptivity

4.2.1. Non-verbal behavior

4.2.1.1 Pretactile Phase of Courtship

Since the authors identified same, or very similar non-verbal behavior, the following text will be based on research articles of Moore (1985), Moore (1995), Grammer (1990), Grammer (1997), Renningeret *al*. (2004), Grammer *et al*. (1999), Weerth & Kalma (1995), for review see Moore (2010). Only in case the statement is unique to single author, the article will be cited in the text additionally.

Generally in this phase, the movements may be divided based on previously mentioned authors by means of which body part is employed: whole body movements (e.g., redirection of body), head position (e.g., facing the communication partner, averted), facial expressions (e.g., various types of smiles, eyebrow flush), arms (e.g., open or closed positions of the body), hands (during gesturing usually occupying the verbal communication, but also touching of a self or other is employed), upper body movement (e.g., lean forwards or backwards), and legs (e.g., open and closed position). Importantly, the movements of each part of the body may occur simultaneously and be communicating different message, which may be reason for confusion.

To draw a scenario, the female is still standing in a distance but has gained attention of one, or several, men in her surroundings. In this phase, the female starts to exchange short smiles, if the eye contact is established, eye brow flush in women may be exhibited – described by Moore (1995) as lifting of one eye brow for a short moment. Also prolonged gazes, and prolonged smiles occur in this phase. Also manipulation of clothes, that actually do not need to be adjusted, may occur, playing with hair of several types differing in head position and length. Importantly, the woman can display her neck, touch herself on the neck occasionally to attract attention to it, moving over to breasts. The manipulation usually happens with palm

presented towards the communication partner. The above described displays are still exhibited on a distance but are directed to one, or possibly several men of her interest. Men will possibly repeat looks, and smiles, taking as much space as possible, if alone, and apart from taking space, also touching others it in a group to communicate their high social status (Renniner *et al.*, 2004).

In the beginning of proceptive phase, gazes and smiles seem to have the most important value, since they communicate interest in the other and positive affiliation between the two communication partners (Moore, 1985, Grammer, 1997, Renninger *et al.*, 2004). Another important movement is arm flexion in women -arm is flexed in elbow and wrist and moved towards the body, usually two or three times. This behavior is namely important since it was preceding approach of the communication partner (Moore, 1995). The approach is usually connected with verbal communication, which will be described in the following section. The non-verbal displays during the interaction can be different when the person is stood or sitting (Moore, 1985). After this point, other men are generally ignored by women (Moore, 1985), and the same can be expected from men. Once the communication dyad is formed, there are three categories of non-verbal signals that would fall in the pre-tactile phase. The first is connected with an interest in the partner which would be characterized by forward lean of the body, frequent gesticulation (namely in women, Grammer *et al.*, 1990), exchanging of smiles, nodding and generally expressing agreement. There seems to be highest communication value of exchanged prolonged looks between the two partners (Moore, 1985, Renninger *et al.*, 2004, Weerth & Kalma, 1995), typically lasting more than three seconds (Moore, 1985). Men display during the whole interaction dominance by taking space, but women namely signalize shines by coy smile, and submission by tilting a head while simultaneously displaying the neck. As for leg position, Grammer (1990) mentions open position of legs as sign of interest, but other authors do not mention it before the tactile phase, where it is connected with caressing (Moore, 1985). In general, synchronization, sometimes called mirroring, is considered sign of high interest in each other within the communication dyad (Grammer *et al.*, 1997, but for extension of the study see Straaten *et al.*, 2008).

The second falls in category of displays is connected with disinterest. The most prominent gesture from female side is so-called head akimbo which consists of both of the arms, crossed, positioned on the back of the head. Interestingly, in men it is gesture of dominance, and is considered rather positive (Grammer, 1990). Other types of negative displays are averted head, leaning backwards, generally loss of attention towards the communication partner,

possibly followed by third category – rejection. As clear signal, negative grooming behavior (such as tooth-picking, nail picking, Moore, 1998), close position of the body (Grammer, 1990, Renninger *et al*., 2004., namely seeMoore, 1998), and complete change of the body posture (Moore, 1998) can be named.

4.2.1.2 Tactile Phase of Courtship

Freund divided the proceptive phase into two parts, pre-tactile and tactile, as opposed to Beach and Money. And it may be hypothesized that the transition between the two is where the actual decision-making happens. In study of McCormick & Jones (2015) this was supported empirically when the researchers observed dyads that showed that during the course of flirtation, both of the sexes used touch as prominent sign of interest addressed to their communication partner, and as the conversation progressed, the pair increased the frequency of touching each other. Especially women were initiators of the touch, but were in control of the course of courting since most of the signals of approval came from their side. Therefore, the physical contact in the later phase of courtship can be understood as relatively separate as suggested by Freund & Blanchard (1986).

In Moore (1985) these signals of interest are mentioned, such as touching the hand, leaning against men´s body by the women, holding hands, hugging, and in few occasions kissing. It is important signal and it seems that the touch is the transitioning part of the stage of proceptivity since in questionnaire study of Jasser (1978) mapping initiation of future sexual activity, and kissing and snuggling was the most common way to signalize interest in sexual activity (22 women, and 21 men out of 22 of each sex), which was followed by allowance of the touch from the partner (20 out of 22 of each sex). In about half of the cases (11 men, 9 women) the signal came from teasing.

Teasing, or playing is also very important part of courting non-verbal behavior in tactile phase. Especially in younger females (Moore, 1995), but is also present in adults (Moore, 2010), this behavior consists of causing various types of light discomfort such as pinching, tickling, and disrespect, such as sticking out the tongue. In other research this behavior was also present, but has been present in men from a bigger part (Hall & Xing, 2014), and was especially present in the very last part of the interaction. Teasing then seems to be another transitional behavior. But sometimes it can be hard to interpret since especially young girls

may use inadequate meant such as fist-punching the boy of their interest (Moore, 2010). The problem with reading the non-verbal behavior in courtship context may be more general.

4.2.1.3 Ambiguity of Displays in Phase of Proceptivity

There is a possibility that since women need time for evaluation of the communication partner intentions and qualities, they may use non-verbal behavior that is ambiguous, namely during the pretactile phase. To extend the time between the transitions from talking to touching, behaviors that do not provide information allowing to distinguish between friendly, generally affiliative behaviors, and signals of sexual interest are employed by women (Reinninger *et al.*, 1990). The same was shown in study by Moore (1995), who conducted a study during which video-tapes of male-female interactions were recorded and later analyzed. The difference between signs of interest and signs of friendly behavior was found not in the specific movement, since it occurred during interaction with male and female counterpart (Moore, 1995) but in frequency only, which may be very hard to evaluate during the actual interaction.

But men, not to lose motivation, seem to react by misperception of the female friendly signal and interpret it as sign of sexual interest in any case as was shown in study of Abbey (1982). In the mentioned study the researchers let male and female participants witness an interaction of a pair from an observatory and their task was to rate how they perceived the interaction. The result shows that the interaction was perceived as more sexual and the female as more promiscuous by male raters in general. Interestingly women face the opposite problem, when dating women. In the book of Rose *et al.* (1993) analyzing courtship scripts of lesbian women, it is described that even the opposite - no signals, or attention at all - may be relevant sign of interest, and as for actions, only direct touch, or verbal communication of interest, is understood as a sign of sexual and partnership interest.

4.2.2. Verbal Communication of Interest

First it should be made clear that even though the verbal communication is the clearest way of communication, lying and deception may be employed. Roney *et al.*, (2003) who found that men "adjust" themselves to match the preference of female that they desire. Interestingly in previously mentioned study of Jasser (1978), the third most prevalent signal for participating

in sexual activity later was direct question (17 females, and 15 male positive answers out of 22 of each sex), but these, even though it is not discussed in the article, apply probably mostly to behavior within the already formed couple. Also indirect talk about sex was prevalent, but in about half of the cases within each sex. In the study of Hall & Xing (2014), conducted on single pairs, it has been shown that namely compliments were present in the initial part of the twelve-minute session coming from men. In the latter parts affirmation (agreeing with each other) was present in the pairs that were attracted to each other from both sides, hence the conversation was affected by the fact that in the initial part the participants were presented with pre-chosen cards with questions. In the very final part, when the conversation was unaffected, mostly verbal teasing was used by men. In Brak - Lamy (2015) completely unaffected real-life scenariosimilar pattern was present, the very beginning of interaction, usually started by male approach, was his complimenting to women. These compliments, probably under influence of environment – night clubs – were of rather explicit, and aimed at sexiness of various body parts, namely if that happens in front of friends of the man. Alternatively, the compliments were aimed on the general looks, or had some funny meaning within. The older the woman was, the more likely her body parts, in an explicit way, were mentioned. Also contact information demands, and pure communication of interest were occurring, namely if looks and smiles were preceding the approach. Women reacted either by engagement in the conversation after, or ignorance of what just happened. If women approached men, they usually did not use verbal strategy, but rather offered drink. If rejected, they were prone to leave the place.

In different type of research, namely rating of dyadic interaction pictured in a movie, the verbal addressing of liking - compliments, hinting - giving space to future meeting, sharing personal details - phone number sharing, but also expressing interest in the other person´s life, such as asking questions, and elaborating on topic discussed increased attractiveness of men and women (Muehlenhard et al., 1986) suggesting that verbalization of cues of interest, even though indirect, increase a possibility of pair formation. There is another methodology that allows focus on purely the verbal side of courting and relationship formation which is to let the participants rely only on messaging with the counterpart. This has been tested in study of Sermat & Smyth (1973) who conducted a study on sample of students (43 of each sex) who interacted with four (two of each sex) trained confederates. This study mainly focused on self-disclosure during partnership interaction. The confederates employed four different strategies differing in degree of disclosure (matching and higher) in two fields (questions and answers).

The study revealed that women tend to be asking more intimate questions but also share more intimate information about themselves. During the interaction, when the confederate matched the communication partner´s level of self-disclosure, but asked more intimate questions gradually the participant preferred future meeting the most. This suggests that namely interest in the other person may have crucial effect on positively evaluated interaction on level of verbal communication with the counterpart.

To further support the argument, and further imply, that namely women seem to prefer to go through more stages of courtship, study of Alberts (1986) can be named. Description of verbal exchanges between men and women in so-called Harlequin Romance Novels has been performed in the study. Although it is addressing imaginary conversations, mainly happening within Western culture, the possible preference can be estimated based on the success of this type of literature amongst women world-wide. The author found that the conversations occur in four phases: initiating – in this phase the couple seems not to find anything in common, and the female heroine seems rather cold andsatirical to the male counterpart, but during the course of initial verbal contact finds something interesting and attractive about the stranger, experimenting – during this phase the conversations seem to be indirect testing of male counterparts intentions to decide whether friendship or relationship is the possible outcome, intensifying – copies the previous part with more explicit intentions for relationship formation and includes more explicitly described decision making, and finally the integration – during this phase the verbal oration of interest is shared, namely initiated by the main female heroine. But there are parts of the conversational exchange that are unique to conversation, and cannot be in any way expressed in the text – the verbal prosody.

4.2.3. Situational Paraverbal Behavior During the Phase of Proceptivity

It has been found that vocal pitch is one of qualities that influence attractiveness of an individual. In men it is low vocal pitch (Apicella *et al*., 2007) and in women it is high vocal pitch (Feinberg *et al.,* 2006), as both of these are attributed to hormonal levels, namely to amount of estrogen in women (Feinberg et.al., 2006) and testosterone in men (Puts *et al*., 2006). It has been found in women, as expected, that pitch increased during interaction with attractive man (Fraccaro *et al*., 2011). But more interestingly, there are other means that are more important during courting, namely so-called prosody. If the melody of the speech, i.e., its prosody, is more varied, raters seem to perceive the communication as more emotional,

whereas if the pitch variability is low, the speaker appears uninvolved in the situation (Wittforth *et al*., 2010). This may be supported by study of Farley *et al*. (2013) that used phone-call records that were recorded during communication with romantic partner and a same-sex friend. Later short clips were played to independent raters who were supposed judge which of the two condition they think they hear the record from. Indeed, the raters were able to distinguish these two conditions suggesting that there is specific communication style, in this case related to lower vocal pitch that is used during speech directed to a romantic partner. But that does address specific situation, when the two know each other but not situation of flirt. The speech is also affected by the attractiveness of the target that the person speaks to. In study of Leongómez et al. (2014), it has been found that speech directed towards the attractive member of opposite sex is more varied in pitch, than when the individual speaks towards an unattractive one, but also men reach in some part of the speech lower pitch than if they speak toward an unattractive one. This study is namely interesting because not only the speech parameters but also perception was tested. The raters were from two different countries (Czech, British) and could not speak the other language, but still they rated speech directed towards an attractive member of both sexes as more attractive. [This article is part of the original papers that constitute part of this thesis]

The initial phase of prosody may differ from the rest of it, as was addressed by Anolli & Ciceri (2002), who let 19 men and 19 women of similar age flirt in laboratory. As is usual, this study was aimed on men´s performance in the scenario and women were rater evaluators of the behavior. The finding shows that there is very specific initial phase of male vocal prosody characterized by higher pitch and increased loudness of speech which was also more varied in pitch. The researchers characterize this initial part as the exhibition of speech, and later this initial part changes. The change is characterized by decreased loudness, less varied pitch and is described by researchers as ´self-disclosure voice´. This study is relatively unique by the fact that if the two communication partners wished to meet after, they had a chance to do so. This happened in those participants that exhibited the above described vocal displays, and did not to those who did not. Arguably, overall attractiveness and experience played roles, hence the result shows importance of vocal modulation during proceptive part. In research of Hughes *et al.* (2010), which interestingly focused not only on male sample but also addressed the changes in vocal parameters in females. In this study physical attractiveness was intentionally manipulated by experimenters. The task consisted of leaving voice-mails to opposite sex individuals who they previously seen on the pictures. This showed that if the

person pictured was attractive, men and women lowered their pitch during the recording. The participants were also asked about their feeling of arousal during the making of a voice-mail record. The self-perceived arousal increased during calling to more attractive member of opposite sex (the participants were not aware that no one will answer, which was part of experimental deception). Furthermore, during the interaction with communication partners, presence of laughter and giggling, communicating positive emotional state, and was described as one of the integralparts of courtship patterns that communicate interest (Grammer 1990, Moore, 1985). As for length of speech, it has been shown by Grammer (1990) that men talk for longer period of time to women, who are in fertile phase, thus men displayed their attraction by this behavior.

4.2.4. Role of Hormones in Phase of Proceptivity

There seem to be important impact of steroid hormone testosterone on the courtship behavior. Namely it is present in men, and its purpose is to enhance the tendency for courting, but also to boost the organism for case of fighting with rivals (Roney, 2009), which has not been systematically supported in case of women. Women have approximately 20 times lower testosterone levels and the metabolism is different, but some studies suggest impact of testosterone on female sexuality in young women (e.g., Udry & Morris, 1986). Thus later in life the situational response is known only during the actual sexual activity, but not before it (Dabbs & Mohammed, 1992). It is relatively clear, that men do, except for extreme cases, fight with other men as is discussed by Archer (2006) in his meta-analytical article. Of 16 articles that provided sufficient information about opponent´s sex for analyses there was not a single case when men would fight women. Men seem to elevate their level of testosterone in reaction to presence of a rival and potential partner. This can be explained by mechanism addressed by so-called "challenge hypothesis" (applied to humans by Archer, 2006), which suggests that there is certain amount of testosterone present in the organism to facilitate the functions dependent on the basal level, and the change of the testosterone level is dependent on the situation, such as presence of the potential partner, or rival, during which the reaction occurs. The role of testosterone in such confrontation seems to be boosting the organism for action (Booth *et al*., 1989). This may be demonstrated by research of Cohen *et al*. (1996), which mapped response of testosterone level after the participant was bumped in, andoffended by being called an "asshole". Participants consisted of students coming from northern and

southern parts of USA. Historically, the southerners are more violent, and with higher possibility would take place in a fight due to historical reasons. As expected, men who came from south not only increased their level of testosterone increased their testosterone more than twice in comparison to control group level, and northerners actually decreased their testosterone level by 10%. Cortisol, another steroid hormone, usually connected with stress and discomfort, level of which elevates in situation of threat (Passelergue, 1999) was elevated in insulted southerners, in comparison to controls and northerners, who in comparison to controls elevated their levels only slightly. Controls always came from the same environment. One of the tasks in the above mentioned experiment was also consisting of finishing of a story, describing scenario, when other male was flirting with main hero's faience. Southerners were more likely to finish the story with a violent ending. Men in competitive fighting sports, the closest comparison to real fight, also elevate their testosterone level in reaction to competition, namely judo fighters were studied (Salvador *et al*., 1987, for review see Archer, 2006).For more, men seem to increase risky behaviors when in presence of a possible mate, as was shown by Ronay & Hippel (2010) on case of professional skateboarders, who were exhibiting riskier rides in front of attractive females, which authors explain as evolved mechanism that originally served to attack other men, if needed. Roney (2009) suggests that based on the fact, that some women highly prefer such traits, in the ancestral times this served as another behavior that could attract the female, or at least decrease number of competitors. The role of cortisol in courtship scenario is rather unclear. It has been shown, that men elevate their cortisol levels after interaction with an attractive member of opposite sex, and this effect was prescribed to feelings of anxiety (van der Meji *et al*., 2010), but in other cases cortisol level elevation was not found to be connected with negative feelings, but rather with preparedness for action (Suay *et al*., 1999). This can be also seen in study of Binter *et al*. (2017) which was conducted on young adult men, and focused on reaction of hormonal levels of testosterone and cortisol. The young adult men were competing for attractive females of their choice with their peers in virtual courtship scenario. All participants were exposed to situation when they believed the female counterpart did choose them, and later rejected them, which is novel aspect of the research. The outcome shows, that there is different response to the situation by those who already have a partner and single men. In case of testosterone, men who did have a partner increased their testosterone level as can be expected from previous literature, but interestingly single men slightly decreased their testosterone levels in reaction to the positive outcome. In dating men, it can be expected that the reaction occurred due to possibility of gaining another partner – short term affair. The slight decrease in singles can be

caused by: (1) change of dating status, which is known to cause decrease of testosterone, and possibly can happen in such short time (2) due to within-group competition that included known competitors which is known to cause little to no hormonal reaction, (3) due to unexpected positive outcome of the competition. As for cortisol, the direction of changes was similar in both, single and dating young men with slight elevation in singles in case of positive outcome, suggesting ether effect of preparedness, or possibly slightly increased anxiety. In sample of partnered participants, the cortisol level relatively increased in response to situation of rejection which can be understood as increase of anxiety caused by loss of higher social status (being partnered). This result is interesting since loss of status caused higher discomfort than loss of potential chance for mating in case of single men. Unfortunately, the emotional states were not controlled for in the research. [This article is part of the original papers that constitute part of this thesis]

Since there are relatively large differences between sexes in in terms of physical aggression, and co-occurring aggressive behavior. In general, it is assumed that women do not elevate their testosterone in reaction meeting their rivals or during physical encounter as men do, nor to situation of courtship. This may be result of use of different tactics, then men do, Bjorkvist (1994) suggested in her theoretical article, that there are no reasons to think that women are less aggressive than men. They just find different ways of aggression that fits better their weaker physical constitution, but better social skills. Therefore, verbal aggression is primary, and physical is employed only in the case of inevitable physical attack. Indeed, it has been found that the competition is not physical as is usual in men but rather gossiping and indirect insults are employed towards other female rivals (Buunk & Fischer, 2009). Co-occurring hormonal response is debatable. Studies that focused on the female competition and could bring insight to the topic, meaning at least physical confrontation is present, provide rather varying results, e.g., Bateup *et al*. (2002) found no relationship between winning and losing in league rugby match, 22% higher level of bioactive testosterone in female wrestlers after the match that did not have any relationship to winning of loss. There is only one published study to date that suggests that courting increases testosterone, and cortisol, in women which used 20 minutes long videos picturing attractive men in courtship scenarios with other women (López *et al*., 2009), but the article does not address possibility that the participants are just jealous of other women pictured, which may be important limitation. Role of other ovarian hormones was explained in the chapter devoted to phase of attractivity, and there is no published study that would suggest situational reaction of any ovarian hormone in reaction to

presence of a partner, but the effects described above supposedly will be present in the phase of proceptivity impacting the preference for masculine men in late follicular phase. There is an interesting study by Gueguen (2009) that was conducted in French bars. The male confederate was asking random women for their contact information, and later asking about the phase of her menstrual cycle. The finding suggests, that normally cycling women, as opposed to pill users, are more likely to share their contact information when in fertile phase of a cycle.

5. Receptivity – The Consummatory Behavior

5.1.   Motivation for Sexual Behavior

Beach (1976) argues that there is very thin line between appetitive and consummatory behaviors (copulation) but he stresses that there is still possibility for rejection of the partner during the transition to receptive phase. Receptivity, in non-human vertebrates, is mainly composed from female assistance in copulation by positioning of the body to allow the male to ejaculate and therefore allow for insemination. Here it should be pointed outthat in the original article of Beach (1967) only male orgasm and ejaculation is addressed, since that is relevant for offspring production. Also the amount of sexual positions that animals employ is relatively low (with rare exception of Bonobo chimpanzees, Wrangham, 1993) and the main aim of the positioning behavior from female point of view is to allow the male penetration, and ejaculation. Hence in humans, the repertoire of activities consists of very complex behaviors, and much more activity is dependent on activity of a women. These activities are often motivated by other means than conception. Indeed, there are more motivations for having sex with someone that were collected in form of statements by Meston & Buss (2007) who asked large sample (over 1500) students to give reasons and found that the offspring production was not mentioned in first fifty most frequent answers to the question, and actually was mentioned as one of the least frequent reasons (approx. 200th form 237 reasons). The actual motivations were by researches divided to four factors, namely to *physical reasons*, including statements such as physical pleasure. The second one was *goal attainment*, including statements such as obtaining resources and status. The fourth was *emotional* addressing love and commitment, and finally the fourth was *insecurity* being motivated by e.g., self-esteem boost. This suggests that having social and sexual partner may not be of a

same value as searching for parent of an offspring. It is important though that the study was conducted on student sample. There were differences between men and women in motivations for sex. Men more often mentioned physical attraction and desirability of their partner, whereas women rated deepening the relationship and love expression as most probable reasons. Though in their long-term partners the vision of marriage and offspring is an important factor (Stewart *et al.*, 2000).

5.2.   *Role of Sexual Fantasy in Human Sexuality*

It may be expected that during the whole process of courtship the two individuals imagine future steps and also fantasize about sexual activity with each other. Sexual fantasies seem to be, human unique, and universal phenomenon that is present in most of the population (Eisenman, 1982; Malamuth, 1981). Sexual fantasies allow us to study male and female psyche without having to consider if they do have committed relationship, and affection of environment on their behavior (Eisenman, 1982, Malamuth, 1981) because in fantasy one can imagine anything one likes, however unrealistic, without experiencing embarrassment or rejection or societal and legal restrictions. Sexual fantasies, therefore, may provide a unique insight into the different scripts that may underlie sexual behavior in men and women (Gagnon & Simon, 1973).

Sexual fantasies may occur outside of any sexual activity, during masturbation, and during actual sexual intercourse (Leitenberg, Dentzer & Srebnik, 1993, Davidson, 1985).In the three contexts, men and women differ in proportion that regularly have fantasies in each occasion. Larger proportion of men had fantasies during masturbation, whereas during actual sexual intercourse women outscored men (Leitenberg, Dentzer & Srebnik, 1993). Sexual fantasy may be triggered spontaneously or be intentionally imagined, or it can be provoked by other thoughts, feelings, or sensory cues (Wilson, 1978). Base on this fact it can be deduced that sexual fantasies may be partly uderstood as planning, or can possibly motivate further behaviors in courtship contexts. Young people were found to modulate their way of behavior in the begging of courting history, namely avoiding past mistakes and finding ways how to be around another person who they desire. The usual age of dating in Euro-American context starts around age of twelve and is peaking around fifteen (Collins & Van Dulmen, 2015), age of first physical contact with the opposite-sex (e.g., holding hands, kissing) around 15, sexual intercourse is between 17 and 18 which is similar age of first serious relationship (Regan *et*

al., 2004). The time between beginning of dating and first serious relationships probably gives enough space to create a picture, including sexual fantasy, of what is preferred in the partner and what is not, also giving space to adjustment of demands and self-perception in reaction to spending time with an opposite-sex peer. Fantasizing about courtship themes is also one of integral contents of sexual fantasy repertoire in case of women, who often picture someone who they are in romantic relationship (Elis & Symons, 1990) especially during the beginning phase of the relationship (Kennair *et al*., 2009), and theyfocus on personal and emotional characteristics of the partner (Ellis & Symons, 1990). Men more likely imagine multiple partners in one fantasy, and their fantasy is rather explicit and related to actual sexual behavior (Zurbriggen & Yost, 2004). It is likely that men take the active position and are dominant, while women tend to prefer submissive, and passive position in theirs (Wilson & Lang, 1981), which isalso true in real life behaviors (Klapilova *et al*., 2016a). Physical features of the partner seem to be namely important to men, who spontaneously provide details about appearance, race, age etc. when asked to describe their sexual fantasy, which is not the case in case of women (Wilson & Lang, 1981). Sexual fantasy content, related to partners and activities present could, and should, be analyzed possibly suggesting presence of a template, or idealization, of such desired partner that later is matched with actual sexual behavior in real life as was suggested by Baumeister *et al*. (2001) and Money (1986). This link between sexual preferences in fantasy topics and real sexual behavior has been researched for case of sexual partners by Binter *et al*. (2012). In this article it has been found that characteristics of partners appearing in sexual fantasies were matching those that were preferred for real sexual behavior. The evolutionary assumptions (Elis & Symons, 1990), related to partner traits such as age, sexual experience, fitness, social factors, were found to predict the choice adequately. Namely in men, we found that the preference is strongest for multiple partners, younger partners, and inexperienced partners. Women in our sample on the other hand reported higher interest in fantasizing but also real-life experience with someone of the same sex. [This article is part of the original papers that constitute part of this thesis]

5.3.   *Non-verbal Behavior in the Receptive Phase*

Sexual positions during the sexual activity also seem to be relatively varied around the globe. The most common sexual position is so-called missionary position, when woman is positioned on her back, with her legs apart, and man is on top of her facing her (Gregersen,

1996). In region of Oceania, modified version of this position is the most typical one. The female is in the same position as in the missionary position, but man is squatting above her (Ford & Beach, 1951). Positions when the woman is penetrated from behind are usually, in non-western societies, employed when the woman is pregnant, or also while standing in case the time for intercourse needs to be minimalized in situation of quick extramarital affair (Gregersen, 1996). Positions during which woman is on top is usually connected with her sexual pleasure and satisfaction as an aim of sexual activity, but such position is usually altered by others within one couple (Gregersen, 1983). Also sexual pleasure is often provided in form of oral sex in case of both partners (Ford & Beach, 1951). In western society, namely Czech citizens, conducted by Klapilova *et al*. (2016b), that from 13 sexual positions. The finding suggests that men and women do prefer different ones. Namely the position in which man is recipient of oral sex is most preferred, and missionary position is associated with least pleasure by men. Women, on the other hand, mostly preferred least penetration from behind and most likely achieved orgasm in position when on top. This is in concordance with the previous research (Ford & Beach, 1951, Gray, 2015), and this is caused by larger impact on rhythm and the movement in general (Safron, 2016, Gray, 2015).

5.4.   *Evolutionary Function of Orgasm*

Beach (1976) stated that in human sexuality research: "The most promising area for initial investigation [related to receptivity] probably would be those aspects of the consummatory pattern which involve the orgasmic response" (p 133). Male orgasm has clear purpose in evolution, ejaculation that leads to conception. In all societies male orgasm and ejaculation were considered inevitable endings of sexual intercourse, not so the female orgasm (Gray, 2015). Only dysfunctions, usually related to increasing age, such as erectile dysfunction, and inability to reach an orgasm (Bautel *et al*, 2002) is affecting the partner choice, and relationship functioning. Namely premature ejaculation, due to its presence in reproductive age (Hatzimouratidis *et al*., 2010). Not only self-esteem is affected (Symonds *et al*., 2003) and may force the affected individual to withdraw from participation in the receptive phase, but also may lead to generally avoiding meeting opposite-sex partners in other than friendly manner. Although most men experience the premature ejaculation sometimes, especially during beginning of a sexual life (McMahon, 1998), there are those for whom it is rather life-long problem (Laumann, Paik, & Rosen, 1999). Even though today we consider the rapid

ejaculation to be rather problematic and dysfunctional, there in an opposite argument coming from Hong (1984) who compared sexual behavior in close species and humans. In his article he argues that perception of premature ejaculation as negative is due to social changes but in the past it could have been selected adaptation. Namely highly sensitive glands, since it allows for fast copulation with semen transmission into female reproductive organs without risking repelling behavior of a female or attacks by other males.

Whether female orgasm is or is not product of evolution is still unresolved but there is number of suggestions regarding the adaptation(s), or byproduct hypotheses. The byproduct hypothesis builds on the fact that men do have an orgasm for evolutionary reasons and the female one is present due to shared development of male and female body (Kinsey, 1953). Symons (1979) addressed this as being of same case as is nipple in men. Men do have nipples but do not breastfeed and their presence can best be explained by shared development with women. Also Gould (1987) famously argued that there is genital homology in the tissues of which male penis and female clitoris develop, which would favor the bias-hypothesis. Though, there are some differences, e.g., possibility of experiencing multiple orgasms which seems to be mainly female domain (Masters & Johnson, 1966). This seems to be relevant argument, but study of Zietsch & Santilla (2011) showed no correlation between siblings in orgasm consistency during sexual intercourse thus the genetic influences can be ruled out as insufficient, therefore challenging the byproduct hypotheses.

Alternative, adaptation supporting hypotheses highlight mainly three functions of orgasm: (a) sperm-transportation which may increase conception, (b) impact of an orgasm on mate-choice, and (c) pair-bonding function of an orgasm. It is important to state that co-existence of more options is possible, or other function may be present in current environment while not being adaptation in through sense of word.

Puts *et al*. (2006) pointed out an important fact about female orgasm related to quality of a partner –women more likely had an orgasm with men who were rated as more masculine and attractive. This may ensure gaining sperm from male of high genetic quality and increase chance of conception with such partner (Thornhill *et al*., 1995). Puts *et al*. (2012) sees function of an orgasm in easier transportation of the sperm towards an ovum. This would be supported by number of authors (e.g., Fox *et al*., 1971, Zervomanolakis *et al*., 2007), and most notably by King *et al*. (2016), who is the first researcher to actually show, albeit on small sample of 6 women, that orgasm provides larger capacity for retention of sperm-like

fluid. This, along with research focused on physiological changes occupying an orgasm such as oxytocin level increase (Zervomanolakis *et al.*, 2007) may increase a chance of fertilization. Furthermore, since women do change their preferences during menstrual cycle towards more masculine men, as argued above (faces: Penton-Voak *et al*, 1999, voices: Puts, 2005, and bodies: Little *et al.*, 2007) and women do have orgasms more likely in the fertile phase of their cycle (Wildt *et al.*, 1998) there would be even higher chance for conception (King *et al*, 2016, Puts *et al.*, 2012). This though may be mainly adaptive in case that more than one mate donates his sperm in short time period (Hrdy, 1986). Therefore, the female orgasm would serve a purpose of a sire choice, which may not be as relevant in these days as it may have been relevant in during some period of our ancestral history (Puts *et al.*, 2012, King *et al.*, 2016).

But in a steady pair also alternative hypothesis should be discussed, which would favor rather investment in the partner by steady relationship. Safron (2016), who described orgasm as a trance-like state that can be achieved by rhythmic entrainment, due to simultaneous firing of neurons. This may have an effect on the long-term partner choice due to possibility of synchronization of the rhythm in the two partners, which strikingly resembles the mirroring or synchronization in the final stage of proceptive phase. Safron also claims that the form of orgasm – single or multiple – may additionally have evolutionary explanation since male orgasm can occur with any partner, and is (usually) one, but female orgasm occurs, more scarcely, with specific partners only but may occur in the multiplied form which implies greater selectivity in women namely for long-term partners. This has been tested by Ellsworth & Bailey (2013) in a questionnaire based study, finding that positive behaviors such as nurturance, providing physical protection, time investment in the partner were positively correlated with female orgasm frequency and intensity. This suggests that the female orgasm may bring benefits in both of the scenarios. And since women presumably will rather repeat sexual intercourse with someone who with they experience orgasm.

But not only orgasm frequency but also overall sexual satisfaction constructs foundation for well working relationship. In longitudinal study of Byers (2005) it has been found that the relationship satisfaction and partnership satisfaction were both influenced by functional intimate communication highlighting importance of closeness. In other studies, it is rather expectable, that sexuality and sexual functioning are related to satisfaction in a pair, as was shown in study of Mark & Herbenick (2014). The researcher used online questionnaire collecting and presented the participants with number of questionnaires to map their

satisfaction. The result of the study implies that both, sexual and overall satisfaction are connected with attraction felt towards the partner and at the current moment and was rather unaffected by attraction felt in the beginning of the relationship. Also study of Klapilova *et al*., (2015) suggests that sexual satisfaction plays important role in the overall relationship satisfaction. The result shows that higher frequency of sexual intercourse, and consistency of vaginal orgasmwere expectedly associated with higher sexual compatibility, but also higher overall dyadic adjustment. Also awareness about the presence of occurring of vaginal orgasm in their partners by men was related to higher sexual and partnership satisfaction in women, which further supports the importance of disclosure within the couple and importance of sexuality in human pair-bonding. There seem to be relatively strong support for the fact that orgasm presence is associated with higher quality of a mate, and also that in steady relationship where the partner provides care and investment. There is a possibility that female orgasm may have had a different function during our ancestral history – selecting between more partners the one who with the conception will occur (supported in comparative review by Puts *et al*., 2012) – but due to social change it serves different purpose – in monogamous relationships – in these days. [This article is part of the original papers that constitute part of this thesis]

5.5.   *Hormonal Response to Sexual Behavior*

Hormonal levels can be affected by long or short term behaviors, physical state, caloric intake, immune system function, lifestyle, and consumption of psychoactive substances (van Anders *et al*., 2011). Testosterone is closely related to sexual functioning in men and its lowering concentration is responsible for decrease of sexual activity and function in aging men (Ferrini & Barrett-Connor, 1998), whose body produces less testosterone in later period of their life, and these functions can be restored by administration of exogenous doses (Steidle *et al*., 2003).Even though sexual reactivity and functioning is often related to testosterone itself (Hellhammer *et al*., 1985), there is inconsistency in this argument. Namely libido and sexual desire, and sexual functioning are not the same thing which is mixed in large part of literature. There can be those who have high testosterone levels but due to various biogenic or psychogenic reasons do not feel desire to have sex, and fail to have sexual intercourse. Also the opposite is possible –hypogonadal men can have sex. The reason is that testosterone is not directly linked to sexual functioning but plays important role in the concerto of physiological

changes that occupy sexual activity including smooth muscle tonus and nitric oxide synthase production (Mills *et al.,* 1996). One of the arguments to support role of testosterone in sexual functioning is use of antiandrogen cure to decrease libido and sexual function in sexual aggressors but this medication affects also nitric oxide synthase production (Mills *et al.,* 1996).

In women this seems to also be true and their sexual desire, and sexual functioning is affected by testosterone serum concentrations, and can be positively affected by exogenous doses in later period of life (Dennerstein *et al*., 2001). But testosterone in women in reproductive seems to be unrelated to sexual functioning (Davis *et al*., 2005). It is though important to have in mind that female body produces much smaller amount of testosterone since male gonads are responsible for production of most of it, and female metabolism of testosterone is different to male one. In healthy women in reproductive age, generally the outcomes of studies on influence of testosterone on sexual response are rather inconsistent (Meston & Frolich, 2000).

There are studies that suggest linear relationship between sexual motivation and desire in both sexes (Simon *et al*., 2005). Young adult men had higher sexual drive, and reported higher number of sexual fantasies if their testosterone level was higher (Shewin, 1987). But further studies revealed that in adult men testosterone level does not relate to sexual behavior in any meaningful way (for short review see Meston & Frolich, 2000). It is important to state that most of the articles focused on role of testosterone on sexual functioning and sexual appetite of men and women do not follow single methodology which may negatively affect consistency of results.

Furthermore, in case of testosterone situational response seems to be rather activity driven, the activity predicts hormonal response but not the other way around which may also add to previously mentioned inconsistency. In study of Dabs & Mohammed (1992) it has been shown that expectation of sexual activity did not cause any effect on testosterone level but sexual activity itself caused increase in both men and women equally. Increase has also been observed in men and women in case of masturbation (Fox *et al*., 1972).

Cortisol levels were found to be, in long-term perspective, impacting sexual behavior negatively (Hammilton *et al*., 2008). The higher the cortisol levels were the more likely men and women experienced negative psychological states such as depression which altered their sexual behavior (Exton *et al*., 2000). Women who were experimentally exposed to erotic

movies and found them arousing situationally decreased their cortisol level, the opposite was true in case of those who did not find the movies arousing. In short-term perspective only men with psychogenic sexual dysfunction seem to be affected, and their cortisol levels situationally increase but it is rather unclear whether the relationship is casual. No other steroid hormone was found to consistently impact sexual behavior. Again, there may be confounding effect of dating status, sexual experience, and in case of women also phase of cycle or use of hormonal contraceptives. All these intervening variables may cover the actualhormonal response, if present.

5.6.   *Verbal and Paraverbal Displays During Sexual Activity*

Two types of vocalization may be present during sexual activity, linguistic and non-linguistic. The linguistic are less present then those non-linguistic ones composed mainly of deep breathing, and interjections. Generally, men do vocalize during sexual activities less often than women but each sex enjoys if their sexual partner vocalizes since it gives them information about current state of their partner. There are not many articles published on the topic but the common information included in all of them is that women are more likely to vocalize, and also to fake the vocalizations (see e.g. Levin, 2006, Younis & Ibrahim, 2015). A small society occurring natural experiment that was originally suggested as rape prevention has shown interesting shift of sexual behavior. The education institution has created a rule that ensured that all activities are understood by both lovers before the activity takes place. To be concrete, taking of every single piece of clothes had to be preceded by description of the act by man, and agreed to woman. The same was true for touching on each part of the body, and penetration. In all cases female permission was required. The rule impacted sexual lives of all students. Since it is rather uncommon to verbalize each of the activity before it happens, it was expected to ruin the joy of sex. But interestingly, women did find this verbal communication arousing and welcomed the change. On the other hand, men were aroused by stimulation that verbally led them, describing women´s state of arousal and verbal communication of her needs. Instructions such as "harder, faster", etc. (Levin, 2006).

Levin (2006) also suggested that female coital vocalization may facilitate bringing the partner to ejaculation which terminates the coitus, especially by intensive vocalization. Other authors (Younis & Ibrahim, 2015) in agreement with this suggestion described similar effect but the termination of sexual activity may be present for various reasons, some of which are

connected with arousal of their partner, giving a partner information they achieved an orgasm but other for reasons such as exhaustion, genital pain. In both of the cases, positive and negative ones, women are faking coital vocalizations. In study of Garde & Lunde (1980) almost 70% of women admitted that they fake orgasm and its vocalizations. Other side of the barricade favors cultural impact of pornography and erotic materials on human sexual behavior. The author sees reason for coital vocalization solely as learned behavior that accompanies the sexual behavior and women vocalize because it is expected from them and favored by men. Though this point of view seems to have limitations, since Kinsey*et al.* (1953) described these vocalizations to be uncontrollable, thus in specific conditions, namely when vocalization would mean ether embarrassment or danger to the pair, these vocalizations can be voluntarily suppressed to certain degree (Levin, 1980).

6. *Summary*

The limit of previous scientific approach in evolutionary psychological literature is lack of understanding of multiple stages that are present in the human mating that would be interpreted in light of partner choice. There is adaptive function of partner choice, which is product of evolution during which especially women test the quality of their potential partners. This testing is present in all three stages of the courting. In the phase of attractivity, partners are chosen based on physicaltraits that signalize health and genetic quality, for further reading see chapter 8 *Sex differences in the incidence of sexual fantasies focused on evolutionary relevant objects*. Hence the article has further implications also for proceptive and receptive stages. Women seem to be affected by hormonal levels in the phase of attractivity to certain degree, depending on their menstrual cycle phase, when in the late follicular phase behaviors, but mainly looks are affected to increase the attention of men. As reaction to presence of an attractive potential partner, especially single men, with elevated testosterone level seem to react by approaching the female, but only in case they get sufficient signal about interest from her side, which is communicated by means of nonverbal behavior.

In the phase of proceptivity, once in a communication dyad, there are relatively specific verbal, paraverbal and non-verbal patterns which are employed, for further reading see chapter 9 *Vocal modulation during courtship increases proceptivity even in naive listeners,*

which falls in the phase of proceptivity. In this phase, men rather use the verbal communication and modulation of voice to signal his interest in the women. Women use various non-verbal cues to affect the speed of courting and many of the signals do not allow, apart from clear signals of rejection, men to understand what the outcome of the courting may be. In latter phase, if the women are attracted to men, they initiate physical contact, very settle in the first part but even whole body contact in the latter, which can be understood as transition to phase of receptivity. During the whole time, especially male behavior is affected by levels of steroid hormones, especially testosterone seems to play major role, for further reading see chapter 10 *Young-Adult Men React with Changes in both Testosterone and Cortisol Levels during virtual within-group Competition for a Desired Partner*. Women seem rather unaffected by rapid changes of hormonal levels in reaction to courting, or at least literature does not provide sufficient explanations. It can be deduced, that since they need to prolong the phase of testing, it would not be beneficial to be under influence of situational hormone change. Also women, as opposed to men, do not typically use physical aggression to deal with concurrency, which namely testosterone is linked to.

In the receptive phase, consummatory behaviors occur. Humans do have broad repertoire of sexual positions and sexual practices that are mostly aimed on male climax. Albeit it is female sexual response, namely orgasm that can affect the choice of the partner and therefore it is, by some, understood as product of evolution affecting the choice of a partner and also satisfaction in current relationship. It may be hard to decide what the adaptation would be response to, albeit there is relatively consistent support for impacts on partner choice and relationship stability. For further reading read chapter 5: *Sexuality satisfaction, sexual compatibility, and relationship adjustment in couples: the role of sexual behaviors, orgasm and men's discernment of women's intercourse orgasm*.

The aim of the proposed thesis is to describe and scientifically evaluate the existence of multiple behavioral and physiological reactions that accompany each stage of human courting and their impact on actual choice of partner.

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Chapter 2

Binter, J., Moyano, N., Leongóomez, J. D., Valentova, J., Jouza, L. & Klapilova, K. (2012). **Sex differences in the incidence of sexual fantasies focused on evolutionary relevant objects***, Anthropologie (Brno),* 50 (1), 83-93.

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SEX DIFFERENCES IN THE INCIDENCE OF SEXUAL FANTASIES FOCUSED ON EVOLUTIONARY RELEVANT OBJECTS

ABSTRACT: Sexual fantasies (SF) are an integral part of human sexuality. In contrast with sexual behavioural displays, which rely to great extend on social factors, they are ideal for studying cognitive adaptations related to sexual differences in mate preferences and motivations. This article examines sex differences in the incidence of sexual fantasies highlighting evolutionary relevant objects across the sample of university students currently involved in long-term relationship (142 women and 121 men). In addition, the intentions to perform sexual activities with these objects were observed. Objects in the checklist of SF (10) were chosen based on evolutionary-psychological literature (e.g., stranger, same sex partner, multiple partner, and inexperienced partner) and were reflected assuming reproductive strategies of both sexes. Supporting evolutionary assumptions, men fantasised more about partners who provide the possibility of increasing fitness with low investment (e.g., multiple partners of opposite sex, $\chi^2 = 19.90$, P < 0.001), and displaying characteristics indicating fertility and youth (much younger partners $\chi^2 = 18.60$, P < 0.001). Women, in contrast, were more likely to fantasise and perform sexual activities with another woman ($\chi^2 = 17.04$, P < 0.001), which is in accordance with recent studies highlighting the plasticity of female sexuality. The evolutionary advantageousness of such sexual activities, however, is debatable. Notably, we found similar patterns in SF incidence and intentions to perform activities with chosen objects, making this study one of the first to prove such phenomena. Based on the results, we suggest that SF highlighting objects represent desired sexual activities that may not be performed because of the existence of social pressure, cultural rules and/or unavailability of (consensual) sexual partner.

KEY WORDS: Sexual fantasy – Evolutionary psychology – Mating strategy – Objects – Sex differences

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INTRODUCTION

Previous research has shown that sexual fantasies (SF) are present in a majority (more than 95%) of the human population (e.g., Davidson 1985, Leitenberg, Henning 1995), thus being an integral part of human sexuality. Furthermore, in contrast with sexual behavioural displays, SF are rather independent of social pressure, cultural rules, availability of (consensual) sexual partner and individual mate-value. For these reasons, SF are suggested to mirror individual sexual preferences more adequately, being the ideal material to study adaptive sexual strategies in both sexes (Baumeister *et al*. 2001, Ellis, Symons 1990).

In his complex definition, Wilson (1978: 9) described sexual fantasies (SF) as "an elaborate story, or a fleeting thought of some romantic or sexual activity. It can involve bizarre imagery, or it can be quite realistic. It can involve memories of past events, or it can be a completely imaginary experience. It can occur spontaneously or be intentionally imagined, or it can be provoked by other thoughts, feelings, or sensory cues. SF can take place outside of sexual activity, or they can occur during autosexual activities or sexual activities with a partner". This definition is employed throughout the paper.

There is a body of empirical evidence concerning sex differences in frequency, incidence, and content of SF. Please note that in this article "incidence" is understood as the proportion of participants having a SF in the whole sample, and "frequency" refers to the number of occurrences of a repeating event per time unit in one person (consistent with Leitenberg, Henning 1995). Previous findings indicate that a) SF in men appear more frequently in a given time period than in women (Person *et al*. 1989), and b) men have more SF of different content in their individual repertoire than women (Wilson, Lang 1981, for a review, see, Leitenberg, Henning 1995).

From the proximate biological perspective, a relationship between the amount of free testosterone and sexual desire has been suggested (Udry *et al*. 1985), which is directly associated with higher frequency of SF; this claim was confirmed by Udry *et al*. (1986). The testosterone level of men is typically about 20 times higher than that of women. Consequently, androgens are supposed to be mediators of selective attention to erotic stimuli (Jones, Barlow 1990) and of appetite for sexual pleasure (particularly for masturbation; see, Zamboni, Crawford 2003). However, the influence of sex hormones and sexual fantasies does not need to be directly causal, but rather feedback-looped. For instance, a noticed erotic stimulus triggers SF and SF trigger masturbation which elicits further sexual imagery that, in turn, increases physiological sexual arousal and androgen levels (Leitenberg, Henning 1995).

From the evolutionary perspective, differences in SF between men and women might have evolved as adaptations to sex-specific constrains in reproductive strategies. According to evolutionary-oriented authors, females cannot increase their reproductive success by increasing the number of sexual partners, while the opposite is true for men (see, e.g., Buss 2002, Buss, Schmitt 1993). Therefore, men who are easily aroused by using their own mental imagery were suggested to be favoured by intrasexual selection, because their better preparedness for the opportunity of occasional copulations increased their reproductive fitness by producing more offspring (Ellis, Symons 1990). Conversely, since women invest more energy and time into successful reproduction, and cannot increase their reproductive success by increasing the number of sexual partners, the presence of sexual imagery evoking immediate preparedness for an occasional copulation with any available partner does not seem to be adaptive. It has been thus suggested that SF in women are more likely to serve different purposes, such as increasing actual sexual arousal. This is supported by studies showing that any sex difference in reported frequencies of SF when no sexual activity is occurring disappear during the context of sexual activities (for a review, see, Leitenberg, Henning 1995).

Here we argue that along with sex differences in frequency and incidence of SF, it is also worthy to study the specific contents of SF in men and women, which might reflect the general sex differences in mating strategies. As Wilson (1987) previously suggested these characteristics could mirror universal patterns, suiting mating strategies for each sex, and can be of adaptive relevance. As outlined above, men can significantly increase their reproductive success by increasing the number of sexual partners and, in line with this, it has been repeatedly shown that in general male SF can be described as focused on sexual novelty and variety (Baumeister *et al*. 2001). In comparison to women, men fantasise about higher number of partners (within a particular fantasy). Moreover, they fantasise about more different sexual objects per person in total within the whole individual repertoire of fantasies (Ellis, Symons 1990, Kinsey *et al*. 1953, for a review, see, Klapilová, Weiss 2009). Furthermore, men have more SF highlighting strangers and multiple partners (Wilson 1997), and Hsu *et al*. (1994) found that men significantly outnumbered women in SF involving a mysterious stranger (40.7 vs. 20.7%) or being involved in an orgy (29.6 vs. 12.3%). Finally, compared

to women, male SF are triggered more often by the presence of an attractive opposite-sex person in their surroundings, or any kind of external erotic stimuli (Gerianne, Sherwin 1991, Schmidt 1975).

It is worth pointing out that, since human offspring need extensive and long-lasting parental care, their survival rate is increased by the amount of parental investment. Consequently, women can increase their reproductive fitness through finding a long-term partner willing to invest in their children and/or to provide paternal care (Trivers 1972). Therefore, an ideal scenario for women is to find someone (e.g., a famous person or an older partner of high social status) who can support her and their offspring by offering sufficient resources (Gangestad, Simpson 1990). In fact, previous studies have confirmed that women have more SF highlighting famous partners than men (e.g., Wilson 1997).

In line with this, an important role of a primary partner in female SF was repeatedly pointed out in previous literature: 20% of women fantasise exclusively about sexual activities with their own partner (Hicks, Leitenberg 2001) and, furthermore, a factor of romantic activities with their own partner was found in studies using PCA analysis of SF content in women – usually described as an "intimate" or "sensual" factor (e.g., Meuwissen, Over 1991, Smith, Over 1991, Wilson 1978). Such activities (oral sex, romantic walk with own partner), when practiced, might increase cohesion of such relationship even though it is clear that only penile-vaginal intercourse (PVI) would lead to reproduction.

Furthermore, several previous studies found that women significantly outscored men in same-sex thoughts (e.g., 21.7% in women vs. 9.4% in men, respectively, Hsu *et al.* 1994). The interpretation of this difference relies mainly on greater sexual plasticity in women, e.g., that women have shown to be more affected by social influences such as public opinion and cultural acceptability (see, Baumeister 2000). From the evolutionary point of view, we hypothesise that for women is risky to have casual sexual contact with a man, because of the lack of guaranty of future investment, but there is no such threat in the case of engaging in sexual activities with another woman which increases chance for occurrence of sexual activities involving women in comparison to casual sex with men (Davies 2004).

THE CURRENT STUDY

Although several previous studies focused on the identification of SF content dimensions (mainly based on performing PCA analysis) (e.g., Alfonso *et al.* 1992, Byers *et al.* 1998, Crepault *et al.* 1976, Crepault, Couture 1980, Meuwissen, Over 1991, Pérez-González *et al.* 2011, Person *et al.* 1989, Reverter *et al.* 2004, Shanor 1978, Wilson 1978), the identification of sex differences in objects accented in SF is difficult, mainly because the authors merge activities and objects into one item of the presented checklist (e.g., being masturbated to orgasm by a partner (Wilson 1978); for a detailed critique see, Methods section). Thus, the empirical evidence for sex differences related to the characteristics of objects in SF is still scarce and incomplete. For the purpose of the current study, we developed a new checklist of SF appropriate for testing sex differences in the incidence of SF focused on objects that meet characteristics regarding the reproductive advantages to one or both sexes. All objects appearing in checklists from previous studies (e.g., multiple partners, stranger) were included along with some new ones (e.g., inexperienced partner) that have not been particularly studied yet, but for which we also expect adaptive differences between sexes. Furthermore, this study is one of the first strictly dividing SF contents into SF highlighting objects and SF highlighting activities (read more in the Materials and methods section). Based on the above reviewed predictions we aimed to test the following hypotheses:

H1: Sex differences will be found in the incidence of SF containing evolutionary relevant objects bringing benefits to the reproductive strategy of each sex (e.g., sex with multiple partners, younger and inexperienced partners will be higher among men, and women will prefer SF with famous, older partners).

H2: Similarly, we expect sex differences in the intention to perform sexual activities with objects with characteristics considered to bring benefits to the reproductive strategy of each sex (e.g., intention to have sex with multiple partners, younger and inexperienced partners will be higher among men, while women will tend to have sex with famous, older partners).

MATERIALS AND METHODS

Procedure

Participants were contacted by researchers (JB, LJ) either in the foyer of the Faculty of Humanities (Charles University, Prague, Czech Republic), or in the student dormitories in Prague. They were asked if they were willing to take part in a study about human sexuality, which includes to complete set of anonymous questionnaires which might contain intimate questions.

Along with the questionnaires, participants who agreed to participate in the study were given a blank empty envelope to guarantee their anonymity. Participants were asked to complete the questionnaires privately; either in their room (in dormitories) or in a prepared empty seminar-room (at the Faculty). All respondents received 50 CZK (2 €) for their participation. A written informed consent form was signed by each respondent.

Participants

The completed questionnaires were obtained from 263 respondents in total (142 women, 121 men). The mean female age was 24.8 years (range = 19–35 years, SD = 5.0 years), and the mean male age was 26 years (range = 18–35 years, SD = 6.8 years). At the time of their participation, all respondents were undergraduate or graduate students (77% of participants were students of humanities; other study programs were present in less than 5% each, e.g., medicine, economics) and had a long-term heterosexual partner. Having a long-term relationship was one of the recruitment criteria; it was specifically defined as "a relationship lasting longer than six months that you find perspective in the future". The choice of the student sample purposely follows the design of some previous studies (e.g., Ellis, Symons 1990, Buunk, Hupka 1987) allowing the comparison of results. Men who identified themselves as bisexuals or homosexuals (scoring higher than three on the Kinsey scale of sexual self-identification) were excluded from the final analysis (N = 8) because homosexual men were found to have different content of SF objects than heterosexual men (Price *et al*. 1985). This procedure was not applied for women due to the less rigid female sexuality (Diamond 2008). It was found that women's self-reported sexual orientation fluctuates during life more often than in men. In fact, the self-identified sexual orientation of women in our sample was distributed more equally all over the (7-point) Kinsey scale (i.e., in contrast to women, men were more likely to use only first two points and were not using the middle (bisexual) part; mean = 1.63, SD = 0.93 for women and mean = 1.33, SD = 0.62 for men). Mean relationship length was 7.5 months for men (SD = 5.4 months) and 12.5 months (SD = 36.6 months) for women.

Questionnaires

We used a questionnaire developed by JB, KK, and JV specifically for this study. The questionnaire consists of four parts: socio-demographic information, details on ideal sexual activity, frequency of real sexual activity, and checklist of SF. The detailed definition of SF

described above (according to Wilson 1978) was at the beginning of each questionnaire to avoid confusion between participants in understanding the term. In contrast with previous research, the checklist of SF contents was divided into two separate checklists: one containing 10 objects with specific attributes (e.g., a stranger, multiple opposite-sex partners) and the second one listing 47 sexual activities (e.g., anal sex, sex in front of an audience) which is not presented in this article. By this separation we tried to avoid the shortcomings of previous studies where both objects and sexual activities were merged into a single item (e.g., you seduce a man who was a virgin, Meuweisen, Over 1991). (Methodological note: this might have led respondents in previous studies preferring one of the two (object/activity) to check the SF as present or rate it high in frequency or excitability, even when the other one of the two (object or activity) was not favoured. Or, alternatively, respondents might have rated them low even if they found one of them arousing, because the other one was not). Given the purpose of this study, only data from SF focused on objects were used. Checklist of SF consisted of 10 evolutionary relevant objects. Objects were chosen based on previous literature: multiple partners, stranger, famous person and same-sex partner were previously analysed by Wilson (1997); own partner is to be one of the most common SF as mentioned in, for example, Shanor (1978) and Hunt (1974); the remaining objects were added to the list because there was a relevant evolutionary based assumption that the object will have some advantage or benefit in terms of sex-specific reproductive strategies (e.g., younger partner for man, older partner for women) (Buss, Schmitt 1993). See list of presented SF objects with explanation of suggested mating strategy relevance in *Table 1*. Each SF was rated for a) incidence (Q: Is this SF present in you repertoire? A: present/not present), b) intention to perform sexual activity with presented object (Q: Have you or would you like to perform the presented SF? A: 1, have not performed it and do not want to do so; 2, have not performed such activity yet, but I want to perform it; 3, I have performed such activity). The Cronbach alpha indicating the internal consistency of 20 items focused on object highlighting SF (10 asked about incidence $\alpha = 0.557$; 10 about will to perform activity $\alpha = 0.758$) was $\alpha = 0.782$.

Data were analysed using SPSS 16.0. Chi-square was used to test sex differences in incidence of SF. Mann-Whitney nonparametric *U* tests were used to test sex differences in the intention to perform SF.

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TABLE 1. List of presented SF highlighting 10 evolutionary relevant objects followed by evolutionary assumptions we suggest based on previous literature.

Objects presented in checklist	Brings more benefits to	Evolutionary reasoning
Sex with own partner	Women	Committed partner invests in offspring, is emotionally close, trustworthy
Sex with some other known person (excluding own partner)	Men/Women	For men represents the way to increase fitness outside the relationship with low (or no) investment; for women the possibility to test a new partner for formation of new relationship
Sex with a stranger of opposite sex	Men	Low investment in eventual offspring, sexual variety
Sex with a famous person	Women	Well situated partner able to invest in offspring
Sex with multiple opposite sex partners	Men	Low investment, possible increase of fitness, sexual variety
Sexual activities with someone of the same sex	Women	No risk of eventual offspring with low quality male partner, forming female-female coalitions
Casual sex with partners of both sexes together	Men	Low investment, while possible increase of fitness partners, sexual variety
Sex with someone inexperienced	Men	Reduces paternity uncertainty
Sex with much a older partner	Women	Well situated partner able to invest in offspring
Sex with a much younger partner.	Men	Reduces paternity uncertainty youth is an indicator of high fertility

RESULTS

Sex differences in the incidence of SF with evolutionary relevant objects

In men, a higher incidence of SF with younger partner ($P < 0.001$), inexperienced partner ($P < 0.001$), multiple partners ($P < 0.001$), and other known person of opposite sex ($P = 0.038$) were found. In women higher incidence of SF with someone of the same sex ($\chi^2 = 17.04$, $P < 0.001$) was found (see *Table 2, Figure 1*). Without excluding homosexual men the result is $\chi^2 = 16.24$, $P < 0.001$, i.e., meaning the result is not

TABLE 2. Sex differences in incidence of SF with evolutionary relevant objects.

Object	χ^2	P-value	Total % in men	Total % in women
Partner	0.34	0.600	78	85
Other known person	5.04	0.038*	77	72
Stranger	0.94	0.333	61	59
Famous person	0.15	1.000	34	36
Multiple partners of opposite sex	19.90	< 0.001***	67	42
Same sex partner	17.04	< 0.001***	11	38
Orgy with both sexes	1.30	0.523	21	26
Inexperienced partner	33.94	< 0.001***	55	21
Much older partner	0.51	0.512	27	25
Much younger partner	18.60	< 0.001***	34	11

Note: Tested by χ^2 test.
Significant results are marked: *, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$.

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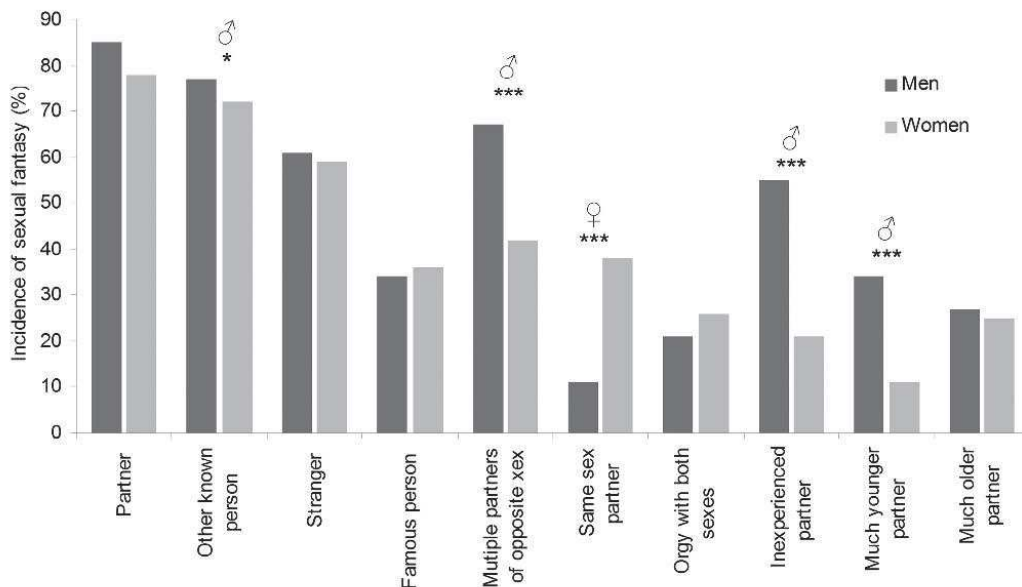
FIGURE 1. Sex differences in the relative incidence of SF accenting evolutionary relevant objects. Note: significant results are marked (*, $P < 0.05$; **, $P < 0.01$; ***, $P < 0.001$). Only positive answers are shown.

biased by excluding part of the data. No other significant sex differences were found.

Sex differences in intention to perform sexual activities with evolutionary relevant objects present in SF

Similar sex differences were found in the experience with or intention to perform sexual activities with evolutionary relevant objects. Men intended and tended to have more sex than women with younger partners ($P = 0.017$), inexperienced partners ($P = 0.010$), strangers ($P = 0.035$), multiple partners ($P = 0.006$), and other known person of the opposite sex (except their primary partner) ($P = 0.046$), while women intended and tended to perform more sex than men with same-sex partners ($P = 0.025$), a famous person ($P = 0.054$), and an older partner ($P = 0.010$) (see *Table 3*).

DISCUSSION

The aim of this study was to test sex differences in the incidence and intention to perform sexual activities with evolutionary relevant objects. In accordance with

TABLE 3. Sex differences in the experience or intention to perform sexual activities with evolutionary relevant objects.

Object	U	P-value	z-value
Partner	947	0.857	−0.180
Other known person	751	0.046	−1.775
Stranger	676	0.0035*	−2.114
Famous person	676	0.054	−1.929
Multiple partners of opposite sex	586	0.006*	−2.751
Same sex partner	606	0.025*	−2.237
Orgy with both sexes	715	0.518	−0.646
Inexperienced partner	706	0.001*	−1.223
Much older partner	537	0.01*	−3.379
Much younger partner	768	0.017*	−0.204

Note: Tested by Mann-Whitney nonparametric U test.
z, z-score (standard score) value.
Significant results are marked: *, $P < 0.05$; **, $P < 0.01$;
***, $P < 0.001$.

our hypotheses we found significant differences in the incidence of SF containing other known person, multiple partners, an inexperienced partner and a younger partner,

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all higher in men, and a higher incidence of SF highlighting sexual activities with a same-sex partner in women. In the case of some SF (older partner, famous person, stranger) the expected sex differences were not found. Similar sex differences were confirmed for the experience with or intention to perform sexual activities with such objects and, moreover, the expected higher intention to have sex with a stranger in men and with famous and an older partner in women was confirmed.

Considering the results we can state that hypothesis 1 (i.e., that "Significant sex differences will be found in incidence of SF containing evolutionary relevant objects bringing benefits to reproductive strategy of each sex") was partially confirmed.

On the one hand, according to the evolutionary-based expectations, objects fitting to the image of an ideal partner were significantly more present in male SF repertoires. Thus, young partners, supposed to display indicators of fertility, youth and higher reproductive potential such as neotenous face, bilateral symmetry, body-mass-index approximately 0.7 (Thornhill, Grammer 1997), as well as inexperienced partners, representing lower risk of uncertain paternity (Beaulieu 2007) and reduced risk of sexually transmitted diseases were overrepresented in men (Beaulieu 2007), even if younger partner was suprisingly present in only about one third of men (34%). As in the case of several following results, this can be explained at the same time by sociocultural factors (Angier 1999, Buss, Schmitt 1993), as differences in socialization processes in sexes, and by the internalization of cultural rules that are in agreement with an evolutionary approach (Oliver, Hyde 1993, Singer 1985); for example, the preference of a virgin female partner is a cultural rule widespread across many societies (Singer 1985). Additionally, the proximate psychological mechanisms can complete the view of this phenomenon, for example, inexperienced men could prefer less sexually-skilled women to avoid the possibility of comparison of their sexual skills with those of other men (Kirkendall 1961). The higher incidence of SF with multiple opposite-sex partners found in men supports our evolutionary-based predictions regarding the evolutionary advantageousness of quantitative reproductive strategy in men, helping them to increase their fitness through spreading their genes as much as possible (Ellis, Symons 1990). Likewise it is in accordance with social deterministic theories pointing out the role of higher social acceptance of male infidelity (Gagnon, Simon 1973) or having multiple mates simultaneously, e.g., he majority of human societies are polygynous (Murdock 1967) in the development of SF

contents. We also suggest that on proximate level this result might be driven by lower socio-sexual restrictiveness (i.e., higher tendency to enjoy uncommitted sexual behaviours with numerous partners), which was repeatedly confirmed in men compared to women (Buss, Schmitt 1993; see also Buss 2002). In the case of multiple partner imagination (and behaviour), there is research showing that finding multiple men in women's fantasies, which is evolutionarily explained by sperm competition, is more likely (Nummi, Pellikka 2012). Although the incidence is lower than in men, the surprisingly high incidence of SF with multiple partners of the opposite sex found in our female sample (42%) could possibly be explained by the bias in our sample in direction to women with low socio-sexual restrictiveness, but unfortunately a measure of this variable was not included in our design. Similarly, the high incidence of SF with a stranger (representing uncommitted sexual affairs with an unknown person) found in women (59%) could be explained by bias in this variable. This could also lead to the non-significant difference in the case of incidence of SF with a stranger, where the expected sex difference was confirmed only by the experience or intention to perform sexual activities with such object. Besides the low commitment that this object impersonates, it also subsumes an important aspect of novelty, which tends to produce higher sexual arousal in men than in women (Baumeister *et al.* 2001), who have been found to react more to known and emotionally closed stimuli (Oliver, Hyde 1993).

In contrast, the expected sex differences in the incidence of SF with objects hypothesised to be adaptive for women were not confirmed. First of all, this result can be caused by the fact that the average man has more types of SF with objects in his repertoire (mean = 6.07, SD = 2.66) than the average woman (mean = 4.93, SD = 2.17) indicating statistically significant difference ($P = 0.002$). Thus, the total percentage of men having each type of SF tends to be higher. This general finding provides strong support for the idea that more men seek for variety in objects. Surprisingly, the incidence of SF with older partners and with famous partners were unexpectedly low for women (for older partner = 25%, for famous person = 36%) in contrast with the incidence of other type of objects, indicating these object are not preferred by women for fantasizing (and neither for men, for whom the incidences were comparable). We suggest that this result is caused by the social environment of our sample; students are surrounded by a large number of attractive people of similar age, resulting in a high

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incidence of SF highlighting other known persons and strangers (present in over 50% in both sexes, making them the SF with the second highest incidence). In contrast, SF with own partner was highly prevalent in women as predicted by previous research (Hicks, Leitenberg 2001, Hunt 1974, Malamuth 1981, Shanor 1978), but was also the most prevalent fantasy in men (70%) and therefore the sex difference was not significant. Compared to previous studies describing the incidence of SF with own partner or intimate activities (Davidson 1985, Meuwissen, Over 1991, Wilson 1978, Wilson, Lang 1981, for a review, see, Leitenberg, Henning 1995), the percentage in our male sample was higher. We suppose that it is due to sampling, because all our participants were currently in long-term relationships (lasting at least 6 months), which they proclaim to find perspective in the future, so that we can expect that they fantasise about their own partners at least sometimes. The sex difference could potentially have been found if we had focused the study on the frequency of having SF with their own partner, where we might expect women to highly outscore men, because of the previously described key role (almost exclusive) of the long-term partner in female sexual imaginary during the first 2 years of relationship (e.g., Pelletier, Harrold 1988); however, this was not the aim of our study.

Special attention should be drawn to the result concerning the "homosexual (or same-sex)" SF. Our results show that they were prevalent in a non-negligible percentage (10%) of our heterosexual male sample (all subjects scoring higher than three on Kinsey scale of sexual orientation were excluded), which is in agreement with the results of Wilson, Lang (1981), who proclaimed that men have SF with other men even if they perceive them as unpleasant. Nevertheless, the high incidence of this type of SF in women (38% vs. 11% in men) could be explained by the less rigid sexuality of human females (Diamond 2008). This is supported by Baumeister (2000), that analysed sex differences in sexual plasticity – women have shown to be more affected by environmental influences such as public opinion or cultural acceptability and were found to have greater sexual plasticity. According to previous studies (e.g., Suschinsky *et al.* 2009), men react by physical arousal (penile erection) only to preferred stimuli, whereas women experience physical arousal in response to any sex-related stimuli (even to video showing chimpanzee copulation, e.g., Chivers *et al.* 2007). The presentation of male sexual stimuli to heterosexual men was frequently followed by erection decrease and unpleasant feelings that were not found in women watching same-sex stimuli (for a review, see, Chivers 2005). Moreover "friendly touching" and even sexual plays, which help to build coalitions and close relationships, are more often seen among females of some close species (e.g., *Pan paniscus*, Parish 1996). Furthermore, evolutionary reasoning would argue that for women there is a high risk in having casual sex with men, because of the threat of conception with less valued men and the lack of guaranty of future investment, while there is no such risk in the case of engaging in sexual activities with another woman. For this reason, sex between two females might be socially accepted more commonly than male-male sexual behaviour (Davies 2004). Therefore, we expect that even the incidence of such kind of fantasy in women is not adaptively inhibited, which is the case of incidence of fantasies with partners that are evolutionary disadvantageous. Herein, it can be argued, that this result could be a by-product of selecting strictly heterosexual men (e.g., scoring lower than three on the Kinsey scale, see sample description). However, the confirmatory analysis shows this is not the case. When the incidence of same-sex SF in the whole sample (when all male participants were included) was tested the difference remained significant ($\chi^2 = 16.24$, $P < 0.001$).

We want to highlight the fact that the same sex differences were found for incidence and for the experience with or intention to perform SF with objects, in addition to other differences confirming our predictions (sex with a stranger in men and sex with an older and famous partner in women). The same argument, therefore, can be applied to discuss the validity of the second hypothesis (H2). However, evidence for the link between SF, defined solely as an imaginative process, and its behavioural displays or tendencies to performance of sexual activity with such objects, is ambiguous. On the one hand, sexual fantasizing with inclusion of preferred (deviant) objects is used in the diagnosis of paraphilia (Davidson 1985, Weiss 2002); for example, a higher incidence of SF containing pre-pubertal children among child molesters was found (Laws, Marshall 1991), but on the other hand one of the common SF contents among normal population (in men as well as in women), a "rape fantasy", was shown to have no association with the "will to act" in reality (Hunt 1974). As we have noted in the introduction, for SF containing evolutionary relevant objects, we assume a universal adaptive pattern and we expect high concordance between imagination and experience or intentions to perform sexual activity with such objects. We suggest they represent the desired sexual activities that are not performed because of the existence of social pressure, cultural rules or availability of

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(consensual) sexual partners (Baumeister *et al.* 2001, Ellis, Symons 1990). Our results indirectly support this assumption.

Finally, we are aware of the several limitations of the study. First, the use of our recruitment criteria can limit the generalisation of the findings. The use of a student sample, even when selected on purpose because of the comparability of results with previous studies that it provides, represents a relatively low proportion of the Czech population (nearly 30% of people aged 20–29 attend university in the Czech Republic (ČSÚ, 2013) differing from other adults. On the other hand, most of the students find their mate during the time of their university studies, making their current sexual fantasy repertoire closely linked to the topic of mating strategies; in fact, the university is one of the common spaces to find a partner (Kalijimin 1998). Choosing a student sample could have also affected our results because university students may perceive their possibilities to find a new partner differently from the rest of the population. Moreover, data might be biased by selecting volunteers, as they can be expected to have a more positive attitude towards sexual topics, increasing their willingness to answer sex-related questions. Moreover, the SF of single or of sexually inexperienced adults can have a different distribution (e.g., the fantasy accenting own partner is irrelevant in such context). In our analysis, we followed the statistical methods used in previous studies focused particularly on sex differences in SF (e.g., Wilson 1987), making the findings easily comparable. However, in future research we suggest to analyse sex differences using the relative incidence of SF highlighting particular objects focusing on female/male repertoires rather than absolute incidence of these objects in a male and female sample. This could help in controlling the results for the higher mean number of SF per person in men and reduce possible bias in the results.

CONCLUSION

As predicted, we found higher frequency and tendency to perform SF with preferred partners according to evolutionary psychological expectations. For men it means significantly higher preference for multiple partners, younger partners, and inexperienced partners. Such partners are considered to be ideal for spreading genes and also decrease paternity uncertainty. The only SF found to have a higher incidence among females was a same-sex partner. It is in agreement with

the findings of previous researcher that have suggested that, compared to male sexuality, female sexuality is less rigid. It can also be explained as lower preference for such SF and activity realization among man whose sexuality is more rigid and innate.

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Chapter 3

Leongómez, J. D., **Binter, J**., Kubicová, L., Stolařová, P., Klapilová, K., Havlíček, J. & Roberts, S. C. (2014). **Vocal modulation during courtship increases proceptivity even in naive listeners**. *Evolution and Human Behavior*, *35(6*), 489-496.

Original Article

Vocal modulation during courtship increases proceptivity even in naive listeners

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ABSTRACT

Speakers modulate their voice when talking to infants, but we know little about subtle variation in acoustic parameters during speech in adult social interactions. Because tests of perception of such variation are hampered by listeners' understanding of semantic content, studies often confine speech to enunciation of standard sentences, restricting ecological validity. Furthermore, apparent paralinguistic modulation in one language may be underpinned by specific parameters of that language. Here we circumvent these problems by recording speech directed to attractive or unattractive potential partners or competitors, and testing responses to these recordings by naive listeners, across both a Germanic (English) and a Slavic (Czech) language. Analysis of acoustic parameters indicates that men's voices varied F_0 most in speech towards potential attractive versus unattractive mates, while modulation of women's F_0 variability was more sensitive to competitors, with higher variability when those competitors were relatively attractive. There was striking similarity in patterns of social context-dependent F_0 variation across the two model languages, with both men's and women's voices varying most when responding to attractive individuals. Men's minimum pitch was lower when responding to attractive than unattractive women. For vocal modulation to be effective, however, it must be sufficiently detectable to promote proceptivity towards the speaker. We showed that speech directed towards attractive individuals was preferred by naive listeners of either language over speech by the same speaker to unattractive individuals, even when voices were stripped of several acoustic properties by low-pass filtering, which renders speech unintelligible. Our results suggest that modulating F_0 may be a critical parameter in human courtship, independently of semantic content.

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1. Introduction

The human voice is remarkably variable. Aside from communication through verbal content, paralinguistic elements of the voice during speech enable individual recognition and assessment of the speaker's physical characteristics such as sex (Puts, Apicella, & Cárdenas, 2012), body size (Feinberg, Jones, Little, Burt, & Perrett, 2005; Xu, Lee, Wu, Liu, & Birkholz, 2013), physical strength (Sell et al., 2010), femininity (Feinberg et al., 2005; Feinberg, 2008), attractiveness (Feinberg et al., 2005; Feinberg et al., 2005; Xu et al., 2013), conception risk (Pipitone & Gallup, 2008), and sexual maturity (Mulac & Giles, 1996). In humans, perceived attractiveness and mate quality can be manipulated by artificially lowering the pitch of male voices or artificially increasing it in female voices, commensurate with sex-typical vocal properties (Collins, 2000; Feinberg et al., 2005). In fact, there is evidence for increased reproductive success in traditional

societies for both low-pitched males (Apicella, Feinberg, & Marlowe, 2007), and high-pitched females (Atkinson et al., 2012).

In addition, vocal parameters can be intentionally varied, for example altering the intensity (loudness), rhythm and pitch. The classic example of such intentional modulation is infant directed speech (IDS) (Ferguson, 1977; Falk, 2005), in which adults alter vocal characteristics such as pitch, cadence and intonation contours when speaking to infants. Infants prefer these altered signals over adult-directed speech (Fernald & Kuhl, 1987), and it has been suggested that IDS aids human acquisition of vocal language (Burnham, Kitamura, & Vollmer-Conna, 2002) and might underpin the origins of musicality (Dissanayake, 2000; Trehub, 2003). In human and animal social interactions, modulations of the intensity of speech or vocalisations are often associated with hostility (Collias, 1960; Kudo, 1987) and dominance (Ohala, 1982; Tusing & Dillard, 2000), and changes in intensity contribute to emotional expression (Baker, 2001). Regarding pitch modulations, men lower their voices during competitive interactions when they perceive themselves as physically dominant (Puts, Gaulin, & Verdolini, 2006), and while women have been found

to increase voice pitch when directing speech towards attractive faces (Fraccaro et al., 2011), both men and women have also been found to lower their voice pitch when speaking attractive targets of the opposite sex (Hughes, Farley, & Rhodes, 2010). This suggests that, while more evidence for specific types of modulation is needed (e.g. in the case women responding to attractive opposite-sex stimuli), modulations do actually occur. Similar subtle modulation in voices might be expected in courtship contexts. In fact, there is evidence of vocal differences between speech directed towards romantic partners and same-sex friends which can be detected by listeners (Farley, Hughes, & LaFayette, 2013), and intentional voice manipulations make female voices, but not male voices, sound more attractive (Hughes, Mogilski, & Harrison, 2013; see also Fraccaro et al., 2013). Indeed, such modulations occur in other species including frogs (Ryan, 1980), koalas, *Phascolarctos cinereus* (Charlton, Ellis, Brumm, Nilsson, & Fitch, 2012), fallow deer, *Dama dama* (Charlton & Reby, 2011), red deer, *Cervus elaphus* (Reby et al., 2005; Reby, Charlton, Locatelli, & McComb, 2010), and birds. For example, in the zebra finch, *Taeniopygia guttata*, males sing more rapidly to females than when they sing alone, producing syllables with lower spectral variability (Kao & Brainard, 2006).

Studies aiming to measure the effects that acoustic parameters have on human communication are hampered by the confounding influence of verbal content. To address this issue, many studies record voices enunciating vowel sounds or speaking standard sentences, or measure responses to voices with artificially manipulated vocal parameters (e.g. Feinberg et al., 2005; Puts, Hodges, Cárdenas, & Gaulin, 2007). These methodologies have provided important insights into the role that vocal parameters play in human communication. Similarly, to study vocal modulation, and unlike research on animals or IDS (where infants understand little or none of the semantic content), it is necessary to control the confounding influence that verbal content may play. Some studies have used scripted speech (e.g. Hughes et al., 2010; Fraccaro et al., 2011), therefore eliminating prosodic variation in vocal acoustic parameters. Although challenging, testing free, unscripted speech is ideal, as standard sentences may not accurately reflect the levels of natural vocal variation; standardised sentences likely limit the kind of spontaneous paralinguistic variation found in normal free speech, as well as the nuance and range of paralinguistic modulation known at least to occur in IDS, which is characterised by an extreme range of pitches, typically starting from a high pitch and containing many glissandos. Finally, while some studies have successfully tested natural vocal variation during speech (e.g. Hodges-Simeon, Gaulin, & Puts, 2010, 2011), apparent paralinguistic modulation in one language may be underpinned by specific parameters of that language (e.g. rhythm, intonation, and use of specific phonemes). Here we circumvented these issues (i.e. the confounding influence of verbal content, using unscripted speech, and the potential effects of one language in paralinguistic modulation) by adopting a cross-language design involving two model languages.

Based on evolutionary theory and the current knowledge of human voices, we hypothesized that males and females would modulate their acoustic parameters (study 1), depending on the sex and attractiveness of the target, to affect the way in which they would be perceived. Because speech intensity is associated with hostility and dominance (Collias, 1960; Ohala, 1982; Kudo, 1987) we expected participants to speak with increased intensity in responses to same-sex targets, in comparison to opposite-sex targets. Furthermore, because emotional expressiveness is attractive (Sprecher, 1989), and changes in intensity improve emotional expression (Baker, 2001), we expected participants to speak with increased variability in intensity when responding to opposite-sex targets, and especially when those targets were attractive. In addition, based on the body of knowledge produced by studies testing perception of manipulated pitch, we predicted that women, and especially men, would emphasise sex-specific vocal characteristics when responding to attractive

individuals of the opposite sex (i.e. lowering F_0 in men, and increasing it in females), and that both sexes would increase F_0 variability, in order to sound more attractive to those attractive targets. Additionally, we predicted that these modulations would be detectable by naive listeners (study 2), and that speakers would sound more attractive when speaking to attractive versus unattractive targets.

2. Study 1

First, we tested the possibility that individuals might alter vocal parameters in speech directed at potential romantic partners or competitors depending on the attractiveness of the listener. Recorded voice samples from speakers of two different languages were used to avoid the possibility that apparent paralinguistic modulation in one language might be reinforced by specific parameters of that language (e.g. rhythm, intonation, and use of specific phonemes).

2.1. Method

2.1.1. Participants
We recruited 110 heterosexual participants who were students at the Universities of Liverpool and Stirling (UK) or Charles University (Czech Republic). Of these, 30 were English speaking males (mean age $\pm$ SD = 22.6 $\pm$ 4.17), 30 English speaking females (21.8 $\pm$ 3.96), 25 Czech speaking males (22.8 $\pm$ 2.30), and 25 Czech speaking females (21.8 $\pm$ 1.84) not suffering from voice hoarseness or nasal congestion. No participant suffered from speech impediments, and all were fluent in English. All participants signed a written consent form.

2.1.2. Target videos
The stimuli were selected from a group of 40 videos, of about 20 seconds in length (mean length $\pm$ SD = 19.3 $\pm$ 2.60), half of which pictured men (mean age $\pm$ SD = 22.5 $\pm$ 2.41) and half women (22.1 $\pm$ 1.65). Individuals were visible from the waist upwards before a white background and were filmed having been asked to introduce themselves to an attractive person of the opposite sex. Each video was rated for attractiveness on a 1 to 7 scale, by an independent panel of 24 opposite-sex raters. From these, the 3 most attractive and the 3 least attractive male and female videos were selected (12 in total). Individuals seen in the videos did not take part in any of the other experiments.

2.1.3. Experimental procedure
After the experiment had been explained and written informed consent obtained, participants were shown the twelve target videos, played without sound to avoid possible effects of pitch convergence (Gregory, Green, Carrothers, Dagan, & Webster, 2001), and asked to record a response message to each one. Participants were told that these messages would be presented to opposite-sex participants who would judge them as a potential date: in the case of responses to opposite-sex targets, participants believed that their messages were going to be presented to the target they were responding to (i.e. the person in the video), while in the case of responses to same-sex targets, participants were told that their responses were going to be presented to all the opposite-sex targets. Participants were instructed to either explain whether and why they would like to date the person in the video (for opposite-sex targets) or why they should be chosen over the person in the video for a date (for same-sex targets). This scenario was based on a study which produced demonstrable effects on mate preferences (Gangestad, Simpson, Cousins, Garver-Apgar, & Christensen, 2004).

After recording their response to each presented target video, participants were debriefed. In total, 1304 recordings were obtained (4 recordings were not collected because the participant recognised the target, and 12 were discarded because of background noise that affected audio quality), with length ranging from 6 to 46 seconds

(mean $\pm$ SD = 14.70 $\pm$ 7.24 s). Additional details are provided in the Supplementary Materials available on-line.

2.1.4. Data analysis

Each recording was acoustically analysed using Praat© 5.2 to obtain data on intensity (dB) and F_0 (Hz). Values were obtained every 10 ms. F_0 was measured using a noise-resistant autocorrelation method, between 75 and 300 Hz for male voices, and 100 and 500 Hz for female voices. Since recordings were of free speech, we did not analyse formant frequencies as these would be affected by the amount and duration of particular vowels. For intensity, only time points for which the Praat algorithm produced a value of pitch were used; this was done to control for any background noise during silent periods and to ensure that intensity scores were unaffected by differences in pause length or number. Finally, we checked that there were no significant differences in length of recordings after viewing attractive and unattractive targets, or depending on target sex.

Means and standard deviations were then obtained for intensity and F_0, and minimum F_0 for males, for each of the 1304 recordings (descriptive statistics of acoustic measures and length of the recordings are presented in Table S1, in the Supplementary Materials). For these values, mean scores were calculated for each participant according to the attractiveness and sex of the target; because each participant responded to three targets of each sex/attractiveness combination, values used in the analysis were the mean of their three responses to same-sex attractive, same-sex unattractive, opposite-sex attractive, and opposite-sex unattractive targets. These were analysed using repeated-measures generalised linear models (GLM) for each parameter (with Bonferroni-adjusted α = 0.0125 because we performed 4 analyses), using sex and language of the participant as between-subjects factors, and sex and target attractiveness as within-subjects factors. We report the within-subjects effects involving attractiveness in Table 1, reflecting the experimental design; the full models are provided in Table S2. Post-hoc pairwise comparisons (t-tests) were conducted for significant effects of target attractiveness. All tests are two-tailed. Additional details are provided in the Supplementary Materials available on-line.

2.2. Results and discussion

Analysis revealed that variability in F_0 (F_0 SD) was particularly sensitive to change in social context compared with the other three parameters (Table 1). There was a significant main effect of target attractiveness, such that F_0 SD increased after viewing attractive compared with unattractive targets. There were also two significant interactions: between target attractiveness, target sex and participant sex (in which men, but not women, raised F_0 SD after viewing attractive individuals in the opposite-sex condition, Fig. 1D), and

Table 1
Context-dependent variation in vocal parameters.

Effect	Vocal parameter							
	Mean intensity		Intensity SD		Mean F_0		F_0 SD	
Within-subject effect	F	P	F	P	F	P	F	P
TA	0	0.99	**8.18**	**0.005**	4.88	0.029	**68.15**	**<0.001**
TA × PS	0.51	0.476	0.03	0.864	0.83	0.364	0.16	0.687
TA × TS	1.37	0.244	1.98	0.162	0.34	0.563	**9.85**	**0.002**
TA × PS × TS	1.71	0.194	0.19	0.661	3.49	0.065	**17.45**	**<0.001**
TA × L	1.28	0.261	0.01	0.921	**7.27**	**0.008**	2.11	0.15
TA × PS × L	1.41	0.239	1.98	0.163	2.22	0.139	0.02	0.9
TA × TS × L	0.46	0.5	4.08	0.046	0.92	0.339	1.28	0.26
TA × PS × TS × L	1.72	0.193	0.35	0.558	1.01	0.317	0.01	0.921

TA = target attractiveness, PS = participant sex, TS = target sex, L = language. Results are from repeated-measures generalized linear models (d.f. = 1, 106 in each case) for each vocal parameter, with Bonferroni adjustment for multiple tests (α = 0.0125). Significant effects are in bold. For all results, see table S1 in the Supplementary Materials.
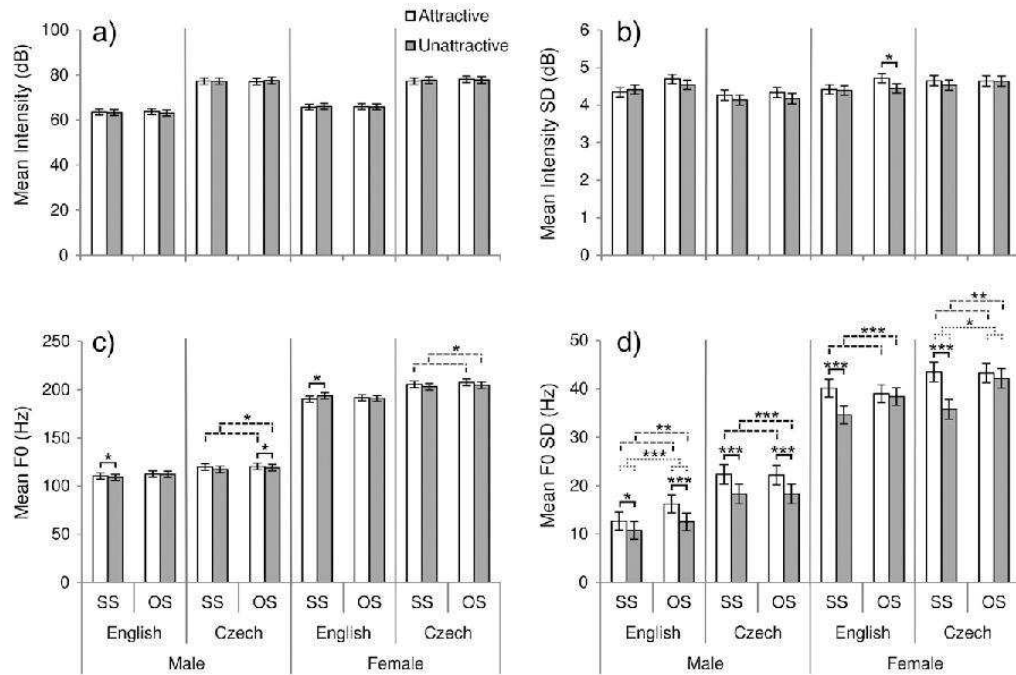
between target attractiveness and target sex (in which F_0 SD was highest after viewing attractive individuals in the same-sex condition). These interactions indicate that men's F_0 SD was higher in the opposite-sex condition, while women spoke with more variability after viewing attractive romantic competitors (Fig. 1D). Previous studies have noted that women are particularly sensitive to attractiveness of perceived competitors, seeking to increase their perceived attractiveness to potential partners relative to other women (Buss & Dedden, 1990; Fisher, 2004), and the differences in F_0 variability that women show after watching same-sex (but not opposite-sex) targets, could be reflecting this. Each of these effects indicate that individuals tended to speak with increased variability in F_0 when motivation was high—in response to perceived attractiveness of potential dates or when competing for a date against an attractive rival. Such variability might serve as a marker of social interest, or help to capture attention of the listener, or could more simply reflect general autonomic arousal in the speaker.

Furthermore, there was striking similarity in these patterns of F_0 SD across the two languages. Post hoc tests showed that differences in F_0 SD during responses to attractive and unattractive individuals of the same or opposite sex (shown in Fig. 1D) occurred in almost identical patterns in English and Czech speakers. This is further illustrated by the absence of any significant interaction involving target attractiveness and language (Table 1, lower panel).

In contrast, there were few context-dependent differences in the other vocal parameters and no similar consistency across languages (Table 1). There were no significant differences in mean intensity. For variability in intensity (intensity SD), there was a significant main effect of target attractiveness, such that participants changed their intensity levels more to attractive individuals, but post hoc tests revealed that this effect was driven mainly by English speakers in the opposite-sex condition (Fig. 1B). There was also a near significant (after Bonferroni correction) interaction between target attractiveness, target sex and language, in which higher intensity SD occurred after viewing opposite-sex attractive individuals in English but not Czech speakers. Finally, for mean F_0, there was a significant interaction between target attractiveness and language, in which Czech (but not English) speakers spoke with high mean pitch after viewing attractive individuals; the main effect of target attractiveness was not significant (after Bonferroni correction) but tended towards higher pitch after viewing attractive individuals.

On the basis of previous studies testing perception of manipulated pitch, we had expected that men might lower mean F_0 when speaking to attractive opposite-sex targets because modulation might serve to emphasise sex-typical characteristics (Hughes et al., 2010), but there were no significant interaction effects involving participant or target sex, and the only significant effects for F_0 corresponded to higher, not lower, pitch in the attractive condition (in Czech speakers; Fig. 1C). However, absence of this expected result can be explained upon recognizing the relative importance of F_0 variability (Table 1; Fig. 1): there was a positive correlation between F_0 SD and mean F_0 (r = 0.46, P < 0.001; Fig. 2A). This suggests that increased variability in F_0 results in higher mean F_0, and that the observed tendency towards higher mean pitch may therefore emerge as a consequence of increasing F_0 variability, rather than being a directly modulated parameter.

Despite this, men's minimum F_0 was significantly lower, in both Czech and English samples, when responding to attractive (M = 82.36 Hz, SD = 6.47) versus unattractive women (M = 86.20 Hz, SD = 9.13) (paired-samples t-test: t_{54} = 5.41, P < 0.001; Fig. 2B) and, in contrast to the relationship between F_0 SD and mean F_0, F_0 variability and minimum F_0 were not significantly correlated (r = −0.11, n = 55, P = 0.44). This suggests that F_0 variability and minimum F_0 are independent parameters which might provide different cues of mating intent and mate quality.

Fig. 1. Modulation of acoustic parameters in speech towards same and opposite-sex targets, split by attractiveness category of the targets (attractive: white bars; unattractive: grey bars) and sex of the stimuli (SS: same-sex; OS: opposite-sex). (a) Mean intensity; (b) intensity SD; (c) mean F_0; (d) F_0 SD. Standard deviation (SD) for intensity and F_0 were used as a measure of variability. Bars represent mean $\pm$ 1 S.E.M. For interactions, dashed lines represent an effect of target attractiveness (attractive, unattractive); dotted lines represent an effect of target sex (same, opposite). Post-hoc tests, *P < 0.05, **P < 0.01, ***P < 0.001. For detailed results, see Table S3 in the Supplementary Material.

3. Study 2

Findings from study 1 indicate that paralinguistic parameters vary depending on the attractiveness of the target, but did not test the perception of this modulation. For it to be functionally relevant and have an effect on mate choice, it must be perceptually detectable and influence proceptivity towards the speaker. Study 2 aimed to investigate whether this is indeed the case.

3.1. Method

In order to test whether paralinguistic modulation is detectable and context-specific, while ruling out influence of verbal content,

we presented subsets of 10 pairs of recordings from each language group to naive listeners (English participants who do not speak Czech, and vice versa) in a series of forced-choice tests. Recordings were judged for attractiveness by both opposite- as well as same-sex listeners. To test context-specificity, we conducted a confirmatory test, in which recordings were rated for friendliness instead of attractiveness. Additionally, and to test whether differences in judgement are dependent on F_0 modulation, low-pass filtered versions of the recordings were rated for both attractiveness and friendliness in separate tests.

3.1.1. Participants

For the test using original voice recordings rated for attractiveness, the final sample included 123 participants judging opposite-sex
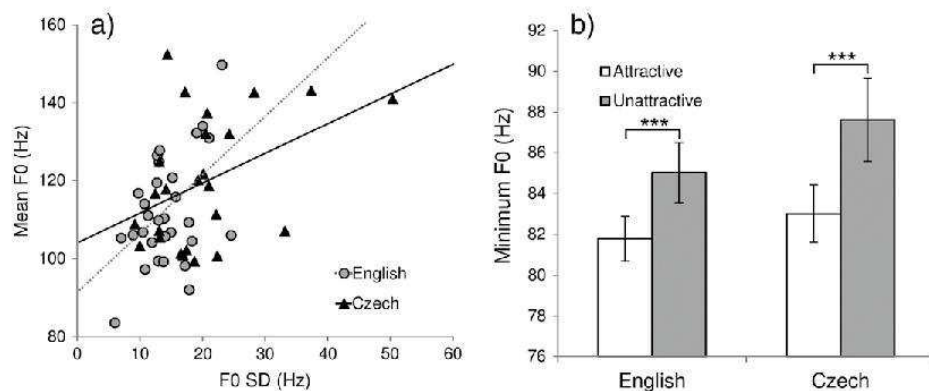
Fig. 2. Relationships between pitch parameters. (a) Correlation between mean F_0 and F_0 variability (F_0 SD) for men's responses to women (English: $r = 0.45$, n = 30, P = 0.012; Czech: $r = 0.41$, n = 25, P = 0.041; all individuals: $r = 0.46$, n = 55, P < 0.001). (b) Men's minimum F_0 in responses to opposite-sex targets (attractive: white bars; unattractive: grey bars). Bars represent mean $\pm$ 1 S.E.M. ***P < 0.001.

recordings, and 98 judging same-sex recordings. Opposite-sex listeners were 24 men (mean age ± SD = 29.2 ± 9.29) and 35 women (27.3 ± 8.89) in the English sample, and 24 men (26.5 ± 7.11) and 40 women (26.9 ± 5.30) in the Czech sample. For same-sex listeners, the equivalent participant numbers were as follows: 25 (24.4 ± 2.93), 32 (24.4 ± 2.95), 20 (23.2 ± 4.88), and 21 (24.6 ± 6.13), respectively. Informed consent was obtained from all subjects.

For the test using the same original voice recordings rated for friendliness, 131 heterosexual participants were recruited. Here, listeners were presented with both same- and opposite-sex recordings (with order fully randomised). The final sample included 108 participants: 23 men (mean age ± SD = 32.7 ± 11.78) and 44 women (30.4 ± 14.79) in the Czech sample, and 15 men (33.3 ± 9.38) and 26 women (28.2 ± 10.17) in the English sample.

For the tests assessing low-pass filtered voice recordings, 174 heterosexual participants were recruited. Again, listeners were presented with both same- and opposite-sex recordings, and because filtering renders speech unintelligible, we relaxed selection for participants who understood a little of the other language. The final sample included 82 participants judging the recordings in terms of attractiveness, and 92 judging on friendliness. For attractiveness judgements there were 22 men (mean age ± SD = 25.6 ± 3.16) and 21 women (24.8 ± 4.18) in the English sample, and 11 men (25.9 ± 5.89) and 28 women (24.8 ± 6.11) in the Czech sample. Equivalent participant numbers judging friendliness were 25 (26.8 ± 6.70), 30 (25.9 ± 4.12), 20 (24.6 ± 5.33), and 17 (23.0 ± 4.62), respectively.

Additional details regarding the exclusion criteria for these tests are provided in the Supplementary Materials.

3.1.2. Audio samples

We used the recorded responses of the first 10 tested participants from each sex/language combination to the most attractive and the most unattractive females as, in the voice recordings, there was significant variation in F_0 SD for both male and female participants (notice that all participants were told their recordings would be presented to opposite-sex participants to be judged as a potential date). Separate tests were also composed using responses subjected to low-pass filtering (Burnham et al., 2002) using Praat© 5.2 with an upper cut-off of 400 Hz (i.e. removing all frequencies above the cut-off level), and standardised to approximately 9 seconds in length (mean ± SD = 8.98 ± 2.28). Low-pass filtering retains variation in fundamental frequency in the voice samples, including minimum F_0, but removes all spectral information above the cut-off point (including most formants) and renders speech unintelligible. Additional details are provided in the Supplementary Materials.

3.1.3. Experimental procedure

Rating tests were conducted online and presented to participants in their native language. Participants were presented with each pair of recordings of the opposite linguistic group, in a different randomised order for each listener. Within each pair, the same voice was directed towards an attractive and an unattractive individual. For the original voices, the research was described as a study of vocal preferences in a foreign language. For the low-pass filtered voices, participants were asked to imagine that they were listening to somebody speaking in a nearby room (because filtered recordings sounded somewhat like this). In all tests, participants were asked to select the recording that sounded either more attractive (i.e. "please listen to both recordings and select the one you think sounds more attractive") or friendly (i.e. "please listen to both recordings and select the one you think sounds more friendly") from each pair.

3.2. Results

First, we compared the extent to which listeners preferred recordings directed towards an attractive target with the level expected by chance (0.5) using one-sample t-tests. In response to the original unfiltered voices, the recording directed towards attractive individuals was chosen as more attractive by opposite-sex naive listeners in every case (Fig. 3a): English men speaking to attractive women were preferred by Czech women more often than expected by chance (t_9 = 15.05, P < 0.001), and the same effect was found for English-speaking women and Czech-speaking men and women (t_9 = 14.57, P < 0.001; t_9 = 20.77, P < 0.001; t_9 = 8.72, P < 0.01, respectively). The same was true of judgments based on the filtered recordings (Fig. 3c): opposite-sex listeners preferred recordings directed towards an attractive target at levels above chance, in each language/sex combination (English men: t_9 = 3.49; Czech men: t_9 = 3.64; English women: t_9 = 3.50; Czech women: t_9 = 5.21; P < 0.01 in every case). We also asked independent groups of listeners to select the recording that sounded friendlier, rather than more attractive, from both the original (Fig. 3b) and low-pass filtered (Fig. 3d) recordings. In these tasks, judgments of neither opposite-sex nor same-sex listeners differed significantly from chance, except in one case, where original recordings of English speaking males were rated by Czech females (t_9 = 3.44; P < 0.01; Fig. 3C). However, in this one case, the strength of preference was lower than in the mate choice context.

To compare these effects directly, we used generalised linear models (GLM) (with Bonferroni-adjusted α = 0.025 because we performed 2 analyses), with rater sex (same, opposite), and context (attractiveness, friendliness), as within-subjects factors, and language (Czech, English) and gender (male, female) as between-subject factors. We tested whether judges preferred responses to attractive individuals depending on the context (attractiveness, friendliness), and sex of the raters (same, opposite), when presented with original, unaltered recordings. We found significant main effects of both context and rater sex (Fig. 3a,b) on the proportion of responses to attractive individuals selected as more attractive or friendly, such that the proportion was significantly higher when recordings were rated for attractiveness than for friendliness ($F_{1,36}$ = 10.27, P < 0.001) and by opposite-sex compared to same-sex raters ($F_{1,36}$ = 63.19, P < 0.001). Furthermore, there was a significant interaction between context and rater sex ($F_{1,36}$ = 50.93, P < 0.001; Fig. 3a,b): in every case, recordings directed towards attractive individuals were chosen as more attractive by a higher proportion of naive opposite-sex listeners (Fig. 3a), but this was not the case when the recordings were rated for friendliness (Fig. 3b). In contrast, neither the language nor the gender of the speakers (nor the interaction between these) had a significant effect on the proportion selected ($F_{1,36}$ = 3.29; $F_{1,36}$ = 0.47; $F_{1,36}$ = 1.11, respectively; P > 0.05 in all cases). For full results, see Table S5 in the Supplementary Materials.

Finally, we tested whether these preferences were preserved after stripping the voices of most acoustic information, but retaining F_0. To do this, the recordings were subjected to low-pass filtering with an upper cut-off of 400 Hz (Burnham et al., 2002). Filtered recordings were then presented in two-alternative forced-choice tasks (as with the original, unfiltered recordings) to listeners from the other language group. Again, rater sex had a significant main effect on the proportion of responses to attractive individuals selected as more attractive or friendly (Fig. 3c,d), with opposite-sex raters selecting a higher proportion of responses to attractive targets than same-sex raters ($F_{1,36}$ = 8.15, P < 0.01). Moreover, and similarly to ratings of original recordings, there was a significant interaction between context and rater sex ($F_{1,36}$ = 5.81, P = 0.021; Fig. 3a,b), in which recordings directed towards attractive individuals were chosen as more attractive by a higher proportion of naive opposite-sex listeners, and neither the language nor the gender of the speakers, or their interaction, had a significant effect on the proportion selected ($F_{1,36}$ = 3.06; $F_{1,36}$ = 0.27; $F_{1,36}$ = 0.15, respectively; P > 0.025 in all cases). Full results are presented in Table S4. The strength of preference for recordings directed towards attractive individuals was
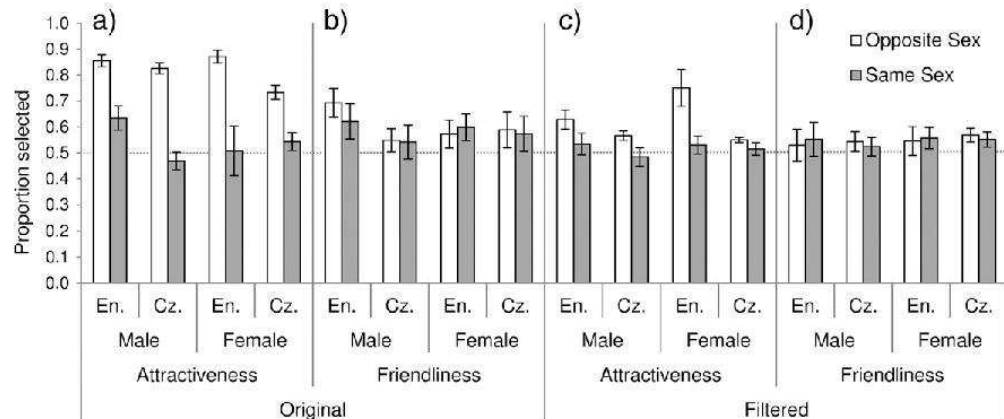
Fig. 3. Mean proportion of recordings towards attractive targets that were selected as more attractive (a,c) or friendly (b,d) by naive listeners. (a) Original recordings, selected as more attractive; (b) original recordings, selected as friendlier; (c) low-pass filtered recordings selected as more attractive; (d) low-pass filtered recordings selected as friendlier. The horizontal axis represents the type of recordings used (original, filtered), the context (whether recordings were judged for attractiveness or friendliness), as well as the gender and language (En.: English; Cz.: Czech) of the speakers in the recordings. In every case, the recordings were rated by judges (opposite-sex: white bars; same-sex: grey bars) from the other linguistic group (i.e. English raters who do not speak Czech, and vice versa). The dotted horizontal line represents a chance level of 0.5. Bars represent mean ± 1 S.E.M. Descriptive statistics are presented in Table S4 in the Supplementary Material.

reduced in comparison to the original, unfiltered voices, indicating that other acoustic parameters also contribute to vocal judgments, but this test nonetheless suggests that modulation of F_0 is sufficient to influence proceptivity in naive opposite-sex listeners. Together, these tests indicate that listeners respond proceptively to pitch information contained within these recordings, but only within the context of mate choice.

4. General discussion

Although previous results suggest that voice pitch plays a role in human courtship (Puts et al., 2006; Fraccaro et al., 2011), our cross-language experimental design provides new insights into the specific nature and mechanisms of paralinguistic modulation involved in courtship. While the two languages (English and Czech) are both European, they lie on separate branches of the Indo-European family with several millennia of largely independent development (Gray, Atkinson, & Greenhill, 2011) and are sufficiently distinct to ensure that semantic content cannot be understood by monolingual listeners. We thus believe that similarities in paralinguistic modulation, and their influence on proceptivity, provide evidence for robust context-dependent sensitivity across languages, but confirmatory studies in other languages and language families are now called for. At least within the two tested languages, however, modulation of F_0 occurred flexibly within a human courtship context in both men and women, and was sufficient to influence proceptivity towards the speaker independently of listeners' understanding of verbal content. Furthermore, the acoustic analysis revealed that variability in F_0 was especially sensitive to manipulation of social context and varied across social contexts in strikingly similar ways across languages.

Hormonal contraceptive use has been shown to affect evolutionary relevant preferences in potential partners (e.g. Puts et al., 2006; Feinberg, DeBruine, Jones, & Little, 2008; Roberts, Gosling, Carter, & Petrie, 2008), and could potentially explain why modulation in F_0 SD in female participants was apparent in responses to other women, but not to men. Future research specifically controlling for hormonal contraceptive use should be conducted to explore this possibility.

Previous studies of the influence of F_0 variability on attractiveness judgments have produced mixed results. Across individuals, higher F_0 variability has been found to be negatively associated (Hodges-Simeon et al., 2010), or not significantly associated (Riding, Lonsdale, & Brown,

2006), with attractiveness, leading Hodges-Simeon et al. (2010) to conclude that further study was needed to determine whether these different findings result from individual differences or contextual variation. Here, our within-subjects design leads us to suggest that, even if individual differences in F_0 variability do not robustly cue attractiveness, speakers do increase variability in F_0 during free speech towards individuals to whom they are attracted.

With the exception of some recent studies (e.g. Riding et al., 2006; Hodges-Simeon et al., 2010) it has generally been assumed that mean F_0 is the key parameter influencing listeners' perception and, specifically, that females prefer low-pitched males. The opposite effect, however, has been reported for red deer, a sexually dimorphic species in which females prefer males with higher F_0 (Reby et al., 2010), questioning the assumption of a general female preference for low-pitched males in mammals. Individual differences in mean F_0 are an important cue for mate quality and attractiveness, but our results suggest that F_0 variability (rather than mean F_0) may be the critical parameter underpinning vocal modulation in human courtship and competition over mates. Men generally tend to speak towards the lower limit of their pitch range (for information regarding human vocal range, see Honorof & Whalen, 2005; Keating & Kuo, 2012), potentially driving mean pitch upwards when they increase variability. Interestingly, men also reached a lower minimum F_0 when responding to attractive women, but minimum F_0 is not correlated with variability, unlike mean F_0. This raises the intriguing possibility that, as low-pitched vocal sounds are physiologically constrained (unlike high pitches; e.g. falsetto) (Lieberman & Blumstein, 1988; see also Fitch & Hauser, 1995), producing a low pitch at some point during an interaction might provide sufficient indication of physical masculinity (Puts et al., 2007) while freeing men to 'play' with their pitch, potentially providing independent cues of both mating intent and mate quality. Furthermore, because low-pitched masculine voices might be associated with aggression (Puts et al., 2012) and because masculinity is often associated with negative attributions (Hodges-Simeon et al., 2010), such modulation could potentially enable men to signal both their masculinity and lack of threat simultaneously, thereby moderating the effect of such negative attributions.

These ideas are consistent with previous suggestions that modulation of F_0 is a general mechanism to signal low or high threat in social interactions (see Hodges-Simeon et al., 2010, 2011; Puts et al., 2012). For example, increased F_0 variability has been associated with positive traits

such as dynamism, femininity and aesthetic inclinations in male speakers (Addington, 1968) or simply friendliness, because adults tend to exaggerate this trait when speaking to infants (Trainor, Austin, & Desjardins, 2000). Alternatively, decreased F_0 variability occurs in competitive contexts (Hodges-Simeon et al., 2010, 2011) and is associated with higher aggressiveness in both foraging and industrial societies (Puts et al., 2012). Thus it could be argued that our results support this, more general, hypothesis—that modulation in speakers' F_0 variability might influence attractiveness assessment indirectly, by increasing perceived friendliness and low threat. However, our perceptual studies suggest this is unlikely: responses to attractive targets were preferred consistently only by opposite-sex listeners, and only when rated for attractiveness (Fig. 3).

Finally, such variability in paralinguistic prosody in courtship contexts has implications for ideas about the evolution of musicality in humans. One important part of musicality is the ability to process the pitch variations that produce the contours and, ultimately, a melody (Peretz & Coltheart, 2003; Peretz & Hyde, 2003). Others have argued that IDS (in which adults alter vocal characteristics such as pitch, cadence and intonation contours when speaking to infants) could be an important component in the development of musicality (Trehub, 2003), in view of characteristic patterns of vocal modulation by mothers and its detection by infants (Fernald & Kuhl, 1987), as well as the effects of IDS on infants' arousal, focus on the mother and strengthening of mother–infant bonds.

Applying the same logic, we suggest that production of similar kinds of vocal modulation during courtship, and its detection and influence on proceptivity, could also be precursors for the development of musicality. In contrast to IDS, vocal modulation in courtship can also help to explain why music and singing is so prevalent in adulthood (Brown, 2000; Fitch, 2006), and why serenading is so prevalent both historically and cross-culturally. Our results thus introduce a new line of support for the hypothesis of an evolutionary origin of music through sexual selection, as first suggested by Darwin (1871).

Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2014.06.008.

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Chapter 4

Binter J., Prossinger H., Bártová K., Krejčová L., Šebesta P., Leongómez J.D., Mueller S. & Klapilová K. (2017). **Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition for a Desired Partner**. Manuscript submitted to *Evolution and Human Behavior* on 12th of April 2017 (under review)

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Abstract

Competitive behaviors elicit hormonal changes in various animal species; the empirical evidence also documents such changes in humans. The most-studied are the steroid hormones testosterone (T) and cortisol (C). To date, such research has been carried out both in physical sport competitions and in various non-physical ones. However, evidence for one critical competition, namely that with peers for desired sexual partners, is currently lacking. Yet winning access to an opposite-sex partner may give ultimate evolutionary advantages. In this study, 88 young adult men competed in a virtual scenario for females with two pre-planned consecutive outcomes: first they were initially chosen by a desired female over peers and later they were rejected in favor of a rival. Hormonal samples were collected before the competition, after positive outcome, and after negative outcome of the competition. Changes in both T-levels and C-levels depended on whether the males already had a regular partner or not. In addition, when comparing competition-related character features, only willingness to form coalitions best explained the T-level changes in the group without a regular partner, as opposed to participants who did have a regular partner in which dominance and ruthless self-advancement mediated the T-level reaction. These findings suggest that the levels of both steroid hormones were affected and that hormone levels and their changes are dependent on partnership status — causing different hormonal responses.

Keywords	Mate choice; male-male competition, testosterone, cortisol
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Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition for a Desired Partner

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Abstract

Competitive behaviors elicit hormonal changes in various animal species; the empirical evidence also documents such changes in humans. The most-studied are the steroid hormones testosterone (T) and cortisol (C). To date, such research has been carried out both in physical sport competitions and in various non-physical ones. However, evidence for one critical competition, namely that with peers for desired sexual partners, is currently lacking. Yet winning access to an opposite-sex partner may give ultimate evolutionary advantages. In this study, 88 young adult men competed in a virtual scenario for females with two pre-planned consecutive outcomes: first they were initially chosen by a desired female over peers and later they were rejected in favor of a rival. Hormonal samples were collected before the competition, after positive outcome, and after negative outcome of the competition. Changes in both T-levels and C-levels depended on whether the males already had a regular partner or not. In addition, when comparing competition-related character features, only willingness to form coalitions best explained the T-level changes in the group without a regular partner, as opposed to participants who did have a regular partner in which dominance and ruthless self-advancement mediated the T-level reaction. These findings suggest that the levels of both steroid hormones were affected and that hormone levels and their changes are dependent on partnership status — causing different hormonal responses.

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1. Introduction

Steroid hormones have short- and long-term effects on physical, psychological, and behavioral levels of the person affected, such as physical appearance (body: Sell et al., 2009, face: Penton-Voak & Perrett, 2000; Puts, 2006), ability to cope with stress (Brown et al., 1996), and several health-related issues (for review see Trigunaite et al, 2015). It is generally accepted that hormonal levels will be situationally modulated in response to reproductive-relevant social situations (e.g. self-perceived status threat; Archer, 2006). These effects could have evolved as a part of complex automatically activated mechanisms in mammalian species to enhance adaptive behaviors such as courtship, mating, fighting or competing for social status and mates (Geniole et al., 2016).

1.1.   Testosterone (T)

T-level changes are related to competition outcome (Geniole et al., 2016). T-levels increase after winning a competition, and decrease when losing (Booth et al., 1989; Archer, 2006; Casto & Edwards, 2016; Wu et al, 2016) and occur in physical confrontations such as judo (Salvador et al, 1987) and non-physical competitions such as chess (Mazur et al., 1992). Moreover, increases in T-levels seem to occur in cases wherein a competitor has or believes to have a direct impact on the outcome, in contrast to scenarios where the competitor has no such impact (e.g. lottery; Mazur & Lamb, 1980). When comparing field research data with those collected in controlled conditions such as in a laboratory, the latter seems to yield more consistent outcomes (McCaul, 1989).

Testosterone is known to be closely linked to sexual behavior (Hellhammer et al., 1985). In a courtship context (exposure to an attractive member of the opposite sex) T-levels of young men increase considerably, whereas in male-male non-competitive interactions they do not (Roney et al., 2003). The encoded actual behavior is explained by a (possibly linear) dependency on T-levels. An alternative to one-way dependency is the so called *Challenge Hypothesis* (suggested for non-human species by Wingfield et al., 1990; introduced to research on humans by Archer, 2006). This hypothesis postulates that basal T-level and situational T-level change may have two different but related functions. The function of basal T-level is to preserve T-dependent mechanisms such as attention to potential rivals and to mates. If such a situation occurs (actual fighting competitors or courting opposite-sex partners) the T-level is responding situationally. Temporarily increased basal T-levels (Mazur & Booth, 1998; Archer, 2006; Roney, 2009) cause young men to be more likely engaged in courtship (Putz et al., 2004) or to have a higher number of sexual partners (Peters et al., 2008). Similarly, in dominant and aggressive men T-level increases during a brief interaction with an attractive female (van der Meij et al., 2008). Roney (2009) also suggested that the situational increase of T-levels functions as preparation to fight a rival; however, it could also be related to interaction with the female sex since women find risky behavior more attractive — thus attributing T-level increase to a situational context reaction. All of the above described mechanisms can have an impact on how men gain access to sexual partners and attain a competitive advantage over other men. The hormonal reaction may be suppressed if members of small coherent groups are striving to maintain cohesion within the group (Flinn et al., 2012, Ciakara, 2011).

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With respect to mating, young men represent a special group: they have elevated T-levels and exhibit riskier behaviors while attempting to attain dominance and to dispose of their rivals by verbal and physical aggression, and are motivated to maximize the chance of gaining access to a sexual partner (Halpern et al., 1998; Archer, 2006). In young adult men, both hormonal changes (Halpern et al., 1998) and high emotional reactivity (Spear, 2009) are possibly linked to the endocrine response.

The effect of relationship status on basal T-level is also known — those who are partnered have lower T-levels compared to single men. This was suggested to have three reasons: (1) the increased T-level is suggested to have an immunosuppressive effect, so energetically it is adaptive to decrease the concentration once it is no longer beneficial; (2) increased attention to potential mates and rivals so risky behaviors are no longer needed (Roney, 2009); (3) there is decreased risk of aggressiveness towards the offspring and increased parenting behavior in low-T men (Gettler et al., 2011). The third effect can occur so rapidly that men presented with a doll reminding them of a baby decreased their T-level considerably within minutes (Berg et al., 2001).

1.2.   Cortisol (C)

As with T-levels, a body of empirically consistent evidence suggests that men also react to competition with C-level changes. C-response is linked to a "fight or flight" reaction (Brown et al., 1996) — an adaptive, self-preserving mechanism activated by perceived threat (Passelergue, 1999). Its actual form could be either physical confrontation or the potential loss of a partner, resources or status. Thus, even though C is usually linked to depression, anxiety, and stress (Brown et al., 1996), there

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also exist positive effects such as elevated attention and the possibility of enacting more physically demanding actions such as physical confrontation. We note that it has been hypothesized that changes in T- and C-levels occur with opposite (numerical/algebraic) signs (Booth et al., 1989), but such response findings seem not reproducible (Mazur et al., 1997). Salvador et al. (1999) studied judo fighters and found hormonal changes to depend on a motivation for winning, thus apparently making the C- (and therefore indirectly the T-) response only part of a complex psychological process. Studies by Zilioli et al. (2012; 2013) show evidence for mutual prediction along both axes, but the inferred correlation may also be modulated by a third variable such as mood or some other mechanism related to response of the nervous system (Denson et al, 2013).

Well documented is the association of C-levels with various psychological stressors, derived from studies that focus on arousal and brain activation, since cortisol also plays a role in mood and memory construction (Booth at al., 2006) even though its primary effect is physiological: the mobilization of energy stores. Elevated C-levels have also been linked to experiencing psychological arousal (Dickerson et al., 2004). In experimental scenarios, mood and T-level changes predicted C-level changes, suggesting that the hypothalamic-pituitary-adrenal axis activation is regulated by emotional states (Zilioli & Watson, 2013): hostility and self-assurance (measured by the Positive and Negative Affect Schedule: Watson & Clark, 1999). However, the specific role of cortisol in courtship scenarios has not yet been sufficiently studied. The only study proposing reaction of C-level to interaction of men with an attractive female, in contrast to an interaction with another male, showed a C-level increase; van der Meji et al. (2009) explained this as a sign of apprehension before courting.

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1.3.   Competition for a desired sexual partner: design and aims of current study

The present study investigates adolescent male competition for a desired sexual partner in an externally controlled scenario (because participants could not affect the outcome) by including both a winning and a subsequent losing condition. We analyzed the impact of the scenario situations on each hormonal level separately. To control for the degree of motivation for gaining the interest of a desired partner, we analyzed the impact for two groups of competing males: those who are currently in a committed sexual relationship and those who are not. We also investigated how these hormone level changes relate to character features of the male participants.

All hormonal samples were collected from saliva at three time points: (1) before the onset of competition; (2) when the desired female chose the participant rather than another peer competitor ("winning situation"); (3) after she had rejected him and implied that she had chosen a rival ("rejection situation").

Based on outcomes found in comparable studies (Booth et al., 2006; Archer, 2006; Casto & Edwards, 2016), we expected: (1) T-levels will rise during the winning situation and decrease in the rejection situation, and (2) C-levels will decrease during a winning situation and increase in response to a rejection. A hormonal reaction to the proposed scenario was expected in non-partnered participants: a more pronounced increase in T-level was to be expected when they are winning, followed by a steeper decrease after rejection — presumably because of the evolutionary benefits brought about by winning versus the threatening consequences of loss of the potential female

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partner. In contrast, the partnered men stand to "just" lose a second or further partner. To evaluate the plausibility of such claims, the two groups — single and partnered men — were analyzed separately, and their hormonal reactions compared, following a comparable design by van der Meji (2010) that compares male-male versus male-female dyad interaction. Here, participants followed the same procedure but differed in their dating status.

2. Materials and Methods

2.1. Participants

The aimed-for samples were young men — secondary school students (aged 16–18 years); they are characterized by high testosterone levels, increased competitiveness and high motivation for mating. The study was presented to them as research about courting strategies, and the true aim was not revealed until after the experiment, during the debriefing. Participants were asked about their current dating status and then assigned to the appropriate group. Of the 88 predominantly heterosexual (scoring < 2 on Kinsey Scale; Pillard, 1990) participants, 35 % currently had a partner. Of these 88 who donated saliva samples for T-level determination, 53 also donated saliva samples for C-level determination; of these 53, 45 % currently had a partner. For participants younger than 18, approval from a legal guardian was obtained. Five high schools within 100 km from Prague, Czech Republic, participated in the study, whose cooperating personnel — biology teachers and educational consultants — did the recruiting. This study was approved by IRB of Faculty of Science, Charles University, Prague (No. 2016/25). Due to fact that the study was conducted on a vulnerable population and deception was

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needed to ensure the reaction is natural, participants underwent two types of debriefing at the end of each experiment. The debriefing was led by a skilled psychologist with training in crisis intervention, who was present at all times as a member of the research team.

2.2. Location

To avoid confounding changes due to circadian hormonal cycles (Purnell et al., 2009; Evans et al., 2008) all experiments started at 8:00 a.m. We used two adjacent classrooms provided by the participating high schools. The first was equipped with a projector and computers in which the animated series *The Simpsons* was shown to ensure a similar mood in all participants. Communication, in particular talking and the use of personal electronic devices, was prohibited. The second room was equipped with video recording devices. Only one participant at a time was present in the second room, where he saw video presentations of focus females, where he recorded his self-presentation video, and where he was later informed about his winning or losing status.

2.3. Female Stimuli

To obtain the female stimuli videos (i.e. of potential mates for whom participants were competing) we contacted a different set of high-schools (to minimize the possibility that participating men and women already knew each other). Each of the 10 volunteering young women (aged 15–17 years) recorded three (each ~3 minute duration) videos in a fixed format but with differing degrees of personal input: (1) her presenting a weather forecast (non-personal), (2) her narrating a part of the *Red Riding Hood* fairy tale (partly personal), and (3) her self-presentation (highly personal).

2.4.   Scenario

In the morning, all participants received instructions and a brief introduction to the scenario, and then filled out questionnaires. To choose one or more of the females, the males underwent a three-stage process. First, they watched 10 of these weather-forecast videos, and were asked to choose three females based on these. Second, after watching video clips in which the three chosen females narrated the fairy tale, each male chose two of these three for the third stage — the self-presentation stage. After the third stage, each male recorded a short (~1 minute) introductory video of himself, which he assumed would be sent to the chosen and presumably desired female. Actual contact with any female never occurred.

Participants were made to believe: (1) that the dating experiment was taking place simultaneously in more than one school (simulating the existence of imagined male rivals; White, 1981); (2) that more than one male participant could choose the same desired female; (3) that female participants would choose to date with only one male from the pool of male contestants from all the competing schools; (4) that females were participating at the same time and were following the two-stage process — first, they are to choose two of all males who had chosen to contact them and, second, they chose just one of them with whom they want to have a date. In fact, all male participants were told they had been chosen by a female first (albeit together with only one other participant — "a winning situation") and, at the very end, that female had rejected them in favor of the rival (a "rejection situation").

2.5.   Hormone Sample Collection

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The collected salivary samples, contained in Salivette test tubes (cotton based; Sardstedt, Rommenrsdorf, Germany) were deep-frozen (following the recommendations of Sellers et al., 2007) and then analyzed in the Institute of Endocrinology in Prague, Czech Republic. Samples were analyzed as described in Ostatníková (2002). Initial samples were collected at the beginning of the experiment ($time_A$); the two remaining ones were collected 15 min after the winning situation ($time_B$) and 15 min after the rejection situation ($time_C$) had been communicated to the male participants.

2.6. Questionnaire

In order to assess the psychological characteristics related to competitiveness of these young adult men we used a 17-item Rank Style with Peers Questionnaire (RSPQ) by Zuroff et al. (2010), which is designed to assess the interaction style people typically use to maintain or improve their social standing among peers. It consists of three almost independent categorical assessments describing the typical interaction style with others: (1) Dominant Leadership, (2) Coalition Building, and (3) Ruthless Self-advancement. All responses were rated on five-point Lickert´s scale, the higher scores being associated with increased tendency for such type of interaction style. Questionnaire data was acquired using Qualtrics.com.

2.7. Statistical Methodology

We used the Maximum Likelihood methodology because it avoids the pitfalls of comparing averages that significance testing methods rely on ("Prosecutor's Fallacy"; Krzywinski & Altman, 2013). Rather than comparing means per se, we compared the most likely (ML) distributions. T-levels and C-levels at all 3 times (prior, win, loss) for

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the two groups (partnered or single) constituted 12 samples, drawn from populations with different or perhaps pair-wise identical distributions. We estimated the ML parameters of three distributions (lognormal, gamma and Weibull) of every sample and determined the ML one. We then used the likelihood ratio test (Prossinger & Bookstein, 2003) to determine the probability that the hormone levels were drawn from two differently distributed populations — or not. We then found the modes and the expectation values of the ML distributions.

The two T-level changes (ΔT-level$_{A \to B}$ and ΔT-level$_{B \to C}$) were modelled as linear functions of all possible combinations of RSPQ scores of the individuals in a group. We used Akaike's Information Criterion corrected for finite sample size (AICc; Akaike, 1973; Takeuchi, 1976) to determine which model had the greatest explanatory power while not modeling statistical noise. The best model in each case was the one for which AICc is a minimum (Burnham & Anderson, 2002).

For a more detailed description of the statistical models used, see the Supplementary Material available online.

3. Results

3.1.   T-levels and T-level changes

At $time_B$, the T-level samples were drawn from a gamma-distributed population. At $time_A$ and $time_C$, the T-level distributions of the two groups (single versus partnered) are different ($P < 0.003$ and $P < 0.03$ respectively; Table 1).

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Fig. 1 shows how T-levels change during the scenario: initially, the single males have a higher T-level mode (i.e. a more likely T-level). At $time_B$, when males were informed of their winning status, the modes of both groups agree (because the samples are drawn from a population with the same distribution). After the scenario has ended ($time_C$), the mode of the partnered group decreases by -16.7% while the mode of the singles again increases by $+5.0\%$, to de facto the same T-level as at $time_A$ (rel. difference $= 0.02\%$).

3.2. C-levels and C-level Changes

Table 2 lists the ML distributions of the C-levels, together with the probability that two distributions are drawn from one single population. We note that initially ($time_A$), the C-levels of all males are two samples drawn from one population (with a gamma distribution). At $time_B$ and at the end of the scenario ($time_C$), the C-level distributions of partnered males differ from those of single males. From $time_A$ to $time_B$, the C-level modes decrease by about the same amount for both samples (by -10.3% for single and by -12.6% for partnered participants), whereas from $time_B$ to $time_C$, the C-level modes decrease by -44.4% for single and by -29.7% for partnered participants (Fig. 2).

3.3. Dependency on Rank Style

Fig. 3 shows model comparisons of the dependency of T-level change on RSPQ scores. For single males, the best model (minimum AICc) includes only one parameter, namely the score for ability to build coalitions, ~~for~~ both for ΔT-level$_{A \to B}$ and for ΔT-

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level$_{B \to C}$. For partnered males, the best model also includes only one parameter, but the scores are 'ruthlessness' for ΔT-level$_{A \to B}$ and 'dominance' for ΔT-level$_{B \to C}$. The models for partnered males have a better explanatory power when the character traits differ from 'coalition'. We note that no combination of more than one score yields a model with a higher explanatory power.

4. Discussion

4.1. Discussion of statistical methodology

The measured T-levels and C-levels have enormously large variances at all three times for both groups. As all distributions must be asymmetric (all hormone levels are positive definite and, furthermore, the expectation values range from 110% to 117% of the mode for T-levels and from 110% to 154% for C-levels), so comparing averages is fraught with misinterpretations and erroneous conclusions. Rather, the modes (the locations of the maximums of the pdf's of the distributions) are informative and enable biological interpretations.

4.2. Discussion of T-level changes

Based on published results, we expected that T-levels would rise on approach to the winning situation and subsequently decrease in both groups contemporaneously. This prediction of universal quasi-parallel change in both groups is not supported in our analysis of the data. Rather, we found that the directions of changes in T-levels depended on whether the participants had a sexual partner or not. The prior T-level in single and partnered men differed by 20%, and the single participants had higher T-levels, in agreement with previous research (Roney, 2009).

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To our knowledge, the findings of the oppositely directed change of T-levels in young males are presented here for the first time. We postulate mechanisms that can explain why T-level changes are oppositely directed.

More specifically, the T-level changes from $time_A$ to $time_B$ increased in the group of partnered participants and decreased for the singles. The increase could be caused by the desire for an extra-pair sexual partner (McIntire et al, 2006). The decrease, observed in the singles group, could be considered support for the hypotheses of Cikiara (2011) and of Flinn at al. (2012) about social cohesion that is maintained due to endocrine mechanisms — little to no reactivity to winning or loss in within-group competitions. This would, though, depend on the outcome of the feelings towards the others within the group. This may be corroborated by the fact that the change in T-levels is explained by only one psychological character in the singles group, namely the preponderance towards coalition building, discussed further below.

An analogous explanation can be derived from findings by Zilioli et al. (2014): during competition for a female, a positive — winning — outcome of the competition can cause an inverted T-level change (namely a decrease) in those who were most surprised by the outcome. In our scenario this explanation makes sense, since participants without a sexual partner were apparently less skilled in dating successfully and their expectations of success were subsequently low.

Another possible cause is that the decrease in T-levels is caused by the immediate change of the self-perceived dating-status when the females expressed their potential interest in the males from the singles group. Perhaps the participants imagined

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themselves as being in a relationship, thus decreasing their T-levels. This phenomenon had been studied previously, when men held an infant doll, in response to which they decreased their T-level as if they were fathers (Berg et al. 2001). Previous publications also stated the decrease in reaction to a change in dating status, namely the evidence in scenarios when two partners are in a long-distance relationship (van Anders & Watson, 2007).

At $time_B$ the T-levels of single and partnered participants had a common distribution, and were acting as if they were members of only one group. The two inverse mechanisms described above may be responsible for bringing the two T-levels together. A further, alternative, possibility can be addressed: a certain T-level is ideal for the nervous system to function optimally in the situation when the young adult men are facing the prospect of courtship. There is need for low aggressiveness, elevated mood, self-confidence but also self-control when interacting with a woman, which participants would emotionally prepare for. This can be best achieved by the right amount of testosterone, which led to a T-level increase in partnered participants and a decrease in singles. Much of this, while consistent with the findings, remains speculative and necessitates further research.

The change in T-levels between $time_B$ and $time_C$ mirrors the change between $time_A$ and $time_B$. Again there is a change in opposite directions; males in the singles group, in particular, return to within 0.02% of their original level — perhaps because the experience of rejection puts participants in both groups back into the same partner

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situation they were in before the response to affection was triggered at $time_B$. To wit, there can be an intervening mood variation, as mentioned by Zilioli & Watson (2012).

To analyze the dependency of these T-level changes on psychological features related to variability in participant's competitiveness, we used RSPQ, because we rely on its good construct validity (Zuroff et al. 2010). Our analyses revealed that the T-level changes of singles were explained exclusively by a tendency to build coalition(s). Restriction (in the AICc sense) to only this personality type can be interpreted as a tendency for maintaining a higher cohesive structure within the group. Their smaller change in T-levels (as opposed to that in the group of partnered individuals) is in agreement with Flinn et al. (2012). On the other hand, this mechanism may be the very reason why they do not have a partner — they compete less for sexual partners. Since self-promotion as a dominant leader has been found to be highly attractive to women (Roney, 2009), coalition builders may appear less attractive — a feature compounded by an apparently low effort manifest in later onset of dating and consequently a fewer number of sexual partners (Putz et al., 2004; Peters et al., 2008).

Remarkably, the partnered participants increase their T-levels when anticipating a further (at least: second) successful sexual relationship. Somehow, their return to their original T-levels after rejection implies something akin to a "Hush-Puppy" effect (Kleiman & Malcolm, 1981; Marlowe, 2000; Geary, 2016): a complex of reactions relating to a resigned settling for an assured sexual partner and a decreased desire for a further sexual affair. If so — and the model calculations support these implications — the return to initial T-levels is best explained by the contrast of traits that value

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individuality — 'ruthless-self advancement' and 'dominant leadership' — versus those that stress communality, such as 'coalition building'.

This state of affairs differs from other views that claim dominance and aggressiveness are associated with higher T-levels. Apparently not so: we observe that those young adult men with higher T-levels are more prone to be coalition-builders. The more 'dominant' and 'ruthless' types have approximately 20% lower T-levels. However, most research about T-levels may not have investigated these in aggressive-type men who have become successfully involved in a sexual relationship.

4.3.   **Discussion of C-Level changes**

We found that the C-levels change occur uni-directionally in both groups during the scenario. Overall, this can be expected due to circadian rhythms (Van Cauter, 1996), but a more detailed comparison of the two groups, which both initially had the same distribution of C-levels, irrespective of partnership status, reveals unexpected details. While the change from $time_A$ to $time_B$ was comparable for both groups, the absolute value of C-level decrease from $time_A$ to $time_B$ was much smaller (about $\frac{2}{3}$) for the partnered group. During the scenario, from the initial value ($time_A$) to the end ($time_C$), the decrease was ~50% for the singles group and ~61% for the partnered group.

The difference between the C-levels at $time_B$ for the two groups appears small in the graph (Fig. 2). Not so, if one looks at expectation values and the most likely values (Table 2). The C-level changes between the two groups during approach to $time_B$ are decisively different. This marked change is even more pronounced by $time_C$: the modes differ by 21 %. We therefore conclude that, as the scenario progresses, the C-levels of

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both groups decrease differently. Van Cauter (1996) has demonstrated that C-levels drop after 8 a.m. in all males. So the drop we observe must be seen as being superimposed over the regular morning-to-noon decrease. We do not have numerical data describing the C-level decrease in the absence of the scenario the participants experienced, therefore we cannot control for it, but we can include in our argument the outcomes of a comparison by van der Meij (2010) of C-level decreases in two comparable groups. In that study, a lesser decrease in C-levels was found to have been caused by increased feelings of stress experienced as a result of male-female interactions. In our scenario, the anticipation engendered by the hope (on the part of a singles male) of a sexual partnership actually forces a lesser decrease of C-levels resulting in higher C-level in singles compared to partnered participants at $time_B$.

Our findings are further corroborated by van der Meij's et al. (2010) assumption that during a brief interaction with an attractive female, men elevated their C-level (more accurately: decreased the levels more slowly). Other studies also suggest that C-levels are higher whenever positive affections were involved (Plihal et al., 1996). In our case, it is likely that apprehension was involved, since the singles group (relatively) increased their C-levels as they (absolutely) decreased their T-levels: an indicator of apprehension.

Differences between the two groups at $time_C$, namely higher C-level in the partnered group, we claim, is a reaction to social threat in a person of higher hierarchical position (partnered participants in our case). Hellhammer et al. (1997) have previously shown that higher rank men increased their C-levels more than lower rank

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men whenever loss occurs. This is also true in our scenario: their higher rank — being defined by dating status — was connected with their higher C-levels. Being informed of rejection therefore caused more discomfort to those who valued their status more even though men in the singles group suffered a greater loss. The evolutionary argument: it is more threatening not to have a partner. By comparison, members of the partnered group went, after rejection, from possibly having two partners to 'only' one. Contrary to our expectation, the C-level of partnered men after rejection was higher than the C-level of single men.

5. Conclusion

The scenario during which young adult men competed for the attention of women of comparable age in a sequence of situations was sufficient to elicit changes in both the men's T-levels and C-levels. Importantly, T-level and C-level reactions depended on their dating status. Single men, whose prior T-level was 20 % higher, surprisingly decreased their T-level in response to being chosen by the desired female. An opposite change occurred in partnered men. The increase in partnered men can be seen as a reaction to the possibility of gaining a further sexual experience, whereas a T-level decrease in singles can be caused by less-competitive attitude or immediate change of self-perceived dating status. After rejection, both groups returned to their original T-levels, which can be understood as re-gaining their original status on the partnership market. We also found that T-level change depended on the type of dominance style within the social group. In partnered males, types having dominance-like ruthless self-advancement and dominant leadership traits played a role in their T-level changes,

whereas for single males the T-level change was solely dependent on the coalition building trait. In contrast to our expectations, C-levels decreased overall during the scenario, probably due to circadian rhythms. However, the C-level was lower in partnered men, relative to single men, during winning; this could be caused by higher apprehension or increased feelings of arousal. During rejection, participants with a partner (a proxy for males with higher status), relative to single men, had a higher C-level, possibly indicative of larger stress.

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Supplementary Material

Maximum Likelihood Methodology

Formally: the most likely (ML) likelihood Λ_{ML} of the given dataset *data* for a distribution $dist(\theta)$ with parameter list θ is

$$\Lambda_{ML} = \Lambda\left(dist\left(\theta_{ML}\right) \middle| data\right)$$

where θ_{ML} are the most likely parameters.

Different hypotheses imply, for the same data set, different distributions. If we define one hypothesis H_0 for a distribution $dist_0$ and another hypothesis H_1 for another distribution $dist_1$, then the likelihood ratio is defined as

$$\text{likelihood-ratio} = \Lambda_{H_0} \middle/ \Lambda_{H_1} = \Lambda\left(dist_0 \middle| data\right) \middle/ \Lambda\left(dist_1 \middle| data\right).$$

The statistic

$$\Lambda = -2\ln\left(\Lambda_{H_0} \middle/ \Lambda_{H_1}\right) = -2\left(\ln(\Lambda_{H_0}) - \ln(\Lambda_{H_1})\right)$$

is approximately χ^2-distributed with $df = 2 + 2 - 2 = 2$ degrees of freedom (because all distributions in the tested hypotheses in this paper have 2 parameters), whenever the sample size is adequately large.

Using AICc for Model Choice

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Formally: we construct a design matrix mat_j with Θ_j (Θ_j being the number of RSPQ in a particular combination j) columns col_j (with j the model number and with K being the number of possible RSPQ combinations; thus $j = 1 \ldots K$) and a dependent vector $vector$ which is one of the four (ΔT-level$_{A \boxtimes B}$ and ΔT-level$_{B \boxtimes C}$ for single and partnered participants) hormone level changes ΔHormone$_i$ $i = 1 \ldots n_{\text{group}}$ for n_{group} participants in each group for each transition. We thus model j matrix equations.

$$mat_j \cdot \begin{pmatrix} a_1 \\ \vdots \\ a_{\Theta_j} \end{pmatrix} = \begin{pmatrix} \text{RSPQ}_{11} & \vdots & \text{RSPQ}_{1\Theta_j} \\ \vdots & \ddots & \vdots \\ \text{RSPQ}_{n_{\text{group}}1} & \vdots & \text{RSPQ}_{n_{\text{group}}\Theta_j} \end{pmatrix} \cdot \begin{pmatrix} a_1 \\ \vdots \\ a_{\Theta_j} \end{pmatrix} = vector = \begin{pmatrix} \Delta\text{Hormone}_1 \\ \vdots \\ \Delta\text{Hormone}_{n_{\text{group}}} \end{pmatrix}$$

A least-squares (LSq) regression implies solving the normal equations for each j to find the best estimators ($\hat{a}_k$ $k = 1 \ldots \Theta_j$) of the Θ_j coefficients in the linear model j, viz.

$$\begin{pmatrix} \hat{a}_1 \\ \\ \hat{a}_{\Theta_j} \end{pmatrix} = \left(mat_j^{\mathrm{T}} \cdot mat_j \right)^{-1} \left(mat_j^{\mathrm{T}} \cdot vector \right)$$

For each model j, the sum-of-squares of the residuals SSR_j is related to Akaike's Information Criterion corrected for small sample size AICc via

$$\text{AICc} = -2\ln\Lambda + 2(\Theta_j + 1)\left(\frac{n_{group}}{n_{group} - \left((\Theta_j + 1) + 1 \right)} \right)$$

$$\text{AICc} = -2\left(\ln\left(\frac{SSR_j}{n_{group}} \right) + \ln(2\pi) + 1 \right) + 2(\Theta_j + 1)\left(\frac{n_{group}}{n_{group} - \left((\Theta_j + 1) + 1 \right)} \right)$$

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with Θ_j parameters and $(\Theta_j + 1)$ degrees of freedom in model j.

Tables

Table 1

Testosterone Level Group $\boxtimes$	Group *singles*		Group *partnered*	Group *singles* $\cap$ *partnered*
$time_A$	Gamma		Lognormal	$P < 0.003$
	mode $= 0.6526\ldots$ E $= 0.7435\ldots$		mode $= 0.5229\ldots$ E $= 0.5937\ldots$	
$time_B$				Gamma
				mode $= 0.6216\ldots$ E $= 0.6830\ldots$ $0.201 < P < 0.203$
$time_C$	Gamma		Lognormal	$P < 0.03$
	mode $= 0.6523\ldots$ E $= 0.7324\ldots$		mode $= 0.5177\ldots$ E $= 0.6052\ldots$	

Table 2

Cortisol Level Group ⊠	Group *singles*	Group *partnered*	Group *singles* ∩ *partnered*
time$_A$			Gamma mode = 5.7454… E = 6.7384… $0.307 < P < 0.308$
time$_B$	Lognormal mode = 5.1549… E = 7.2150…	Weibull mode = 5.0205… E = 4.9807…	$P < 0.003$
time$_C$	Gamma mode = 2.8630… E = 4.4155…	Lognormal mode = 3.5312… E = 3.8879…	$P < 0.002$

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Table 3

Cortisol Level	Group	Most likely Distribution	Evidence Ratio < 2
$time_A$	partnered	N/A	
	single		
$time_B$	partnered	Weibull	1
		Gamma	1.43
	single	Lognormal	1
$time_C$	partnered	Gamma	1
		Lognormal	1.02
		Weibull	1.47
	single	Gamma	1
		Weibull	1

Table Captions

Table 1 The result of the ML distribution analysis of the T-levels. At $time_A$ and $time_C$, the probability that the samples of single and partnered participants have been drawn from the same population is low (for $time_C$) and very low (for $time_A$). At $time_B$, the probability that the samples $group_{partnered}$ and $group_{single}$ have been drawn from different populations cannot be supported by the likelihood ratio test ($P \approx 20\%$). The T-levels

for the sample of singles are gamma distributed at both $time_A$ and $time_C$, and are

lognormally distributed at $time_A$ and at $time_C$ for partnered participants. The probability

that the two samples/groups (single and partnered) at $time_B$ are drawn from the same

(gamma) distributed population is high: $\sim 80\%$. The mode is the most likely T-level for

the distribution and its expectation value is abbreviated E; these values have been

determined using the ML parameters of the most likely distribution, not via estimators

for the sample. Observe that the modes are always less than the expectation values —

indicating that the most likely distributions are asymmetric. Further details are

elaborated in the text.

Table 2 The result of the ML distribution analysis of the C-levels. At $time_B$ and $time_C$,

the probability that the samples of single and partnered participants have been drawn

from the same population is very low. At $time_A$, the probability that the samples of

single and partnered participants have been drawn from different populations cannot be

supported by the likelihood ratio test ($P \approx 31\%$). At $time_B$, the C-levels for sample of

singles are lognormally distributed, whereas they are Weibull (or gamma; see Table 3)

distributed in partnered participants. At $time_C$, the sample of singles is gamma (or

Weibull; see Table 3) distributed, whereas the sample of partnered participants is

gamma (or lognormal or Weibull; see Table 3) distributed.

Table 3 Evidence ratios that indicate whether a most-likely distribution of a specified

sample is unique. At $time_A$, the two samples are drawn from one population, so

evidence-ratio calculations are meaningless. At $time_B$, there is insufficient evidence for

distinguishing between the sample of partnered participants having been drawn from a

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Weibull-distributed or a gamma-distributed population, whereas all evidence ratios for sample of singles drawn from a population with a distribution other than the lognormal distribution are greater than 2. At $time_C$ the evidence ratios for distinguishing distributions for the sample of partnered participants are all so close to 1 that we cannot uniquely assume the sample has been drawn from a gamma-distributed population (nor does it matter). Similarly, at $time_C$ the evidence ratios show that the sample of singles could have been drawn from either a gamma-distributed population or a Weibull-distributed population. If distributions (other than normal distributions: see below) are not shown in this table, their evidence ratios are very much larger than 2 and these distributions must be considered unlikely. Note: a priori considerations exclude the possibility that any hormone level sample has been drawn from a normally distributed population (hormone levels are bounded from below by 0 and consequently the distribution population from which the sample has been drawn cannot be symmetric).

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Figure Captions

Figure 1: The T-levels and their transitions for both groups during the scenario. Observe that the likelihood ratio test shows that the T-level distribution at $time_A$ and $time_C$ are significantly different, whereas during $time_B$ the T-levels are two samples drawn from a population with the same distribution (with a very high probability). The T-levels for male participants without a sexual partner decrease and then increase back to almost pre-scenario levels, while the converse, albeit with a larger change, is the case for male participants with a regular sexual partner. Because none of the distributions of the populations from which the samples have been drawn are symmetric, the modes (the most likely values — the positions of the extremes in the $pdf\left(dist\left(\theta_{ML}\right),t\right)$), rather than averages, have been graphed (as black circles).

Figure 2: The C-levels and their transitions for both groups during the scenario. Observe that the likelihood ratio test shows that the C-level distribution at $time_B$ and $time_C$ are significantly different, whereas at $time_A$ the C-levels are probably two samples drawn from one population. The C-levels for all males decrease, albeit with a larger change for single males. Because none of the distributions of the populations from which the samples have been drawn are symmetric, the modes (the most likely values — the extremes of the C-levels in the $pdf\left(dist\left(\theta_{ML}\right),t\right)$), rather than averages, have been graphed (as black circles). As a consequence of using ML methods, the two outliers at $time_B$ for the sample of partnered participants do not change the mode, and therefore need not be discarded — avoiding at least one contentious issue when means and t-tests are used. For further details, see text.

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Figure 3: The use of AICc (Akaike's Information Criterion, corrected for finite sample size) to determine which of the characteristics 'dominance', 'coalition' or 'ruthless' — or any of their combinations — explains the change in T-levels during the two time intervals in the scenario. Shown is the result for the group of single males. The model with the minimum AICc (here scaled to 1.000… for the minimum) is the model that best fits the data (in the least squares sense) without also modeling statistical noise. Remarkably, only the character trait 'coalition' best models the change in T-levels for both transitions. The dashed lines connecting the points in the graph are only drawn to improve readability; they have no statistical relevance.

AICc (scaled)

1.180
1.160
1.140
1.120
1.100
1.080
1.060
1.040
1.020
1.000

$\Delta\text{T}-\text{level}_{A \rightarrow B}$

$\Delta\text{T}-\text{level}_{B \rightarrow C}$

Model

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ruthless
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dominance ∧ ruthless
coalition ∧ ruthless
dominance ∧ coalition ∧ ruthless
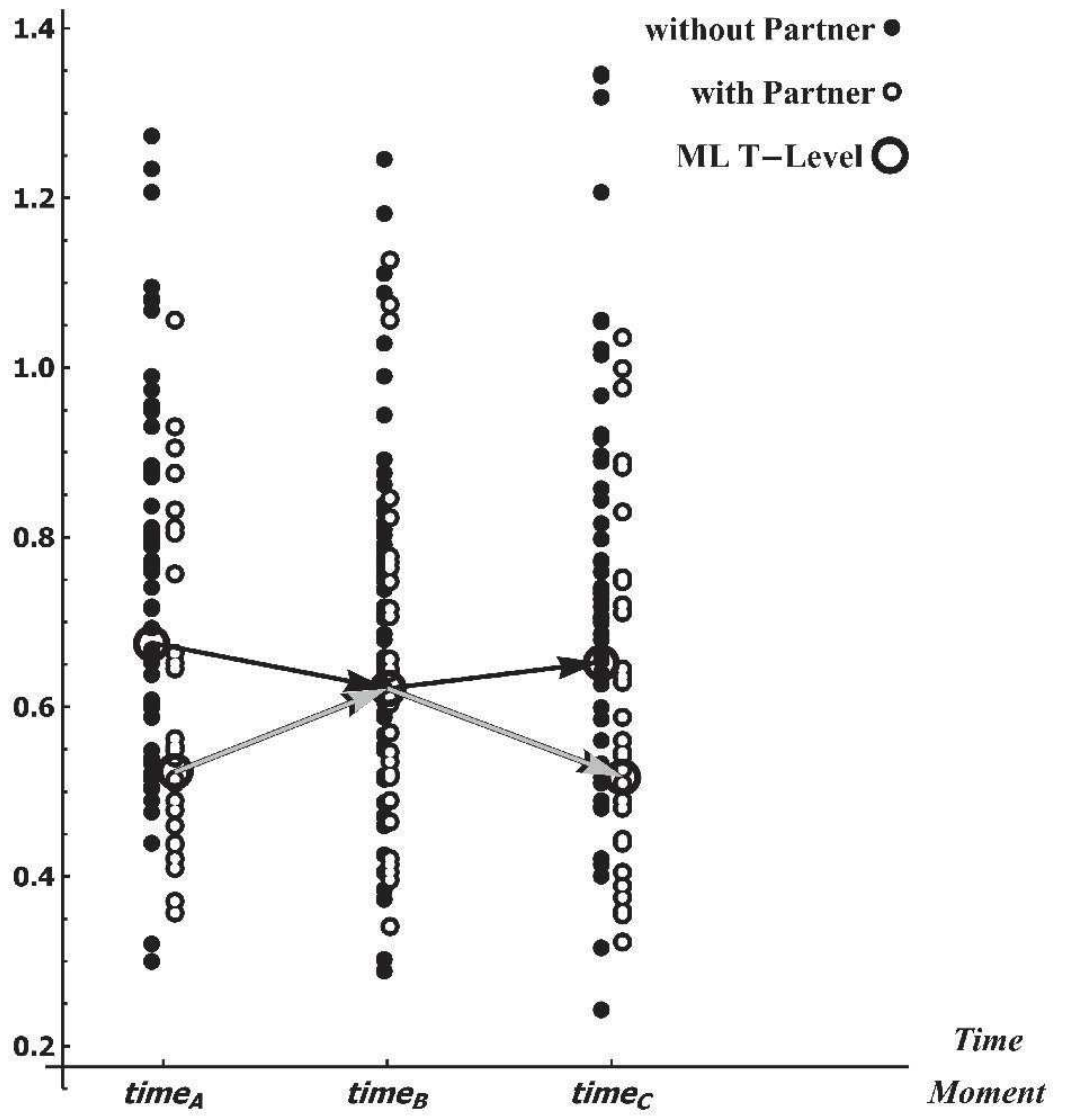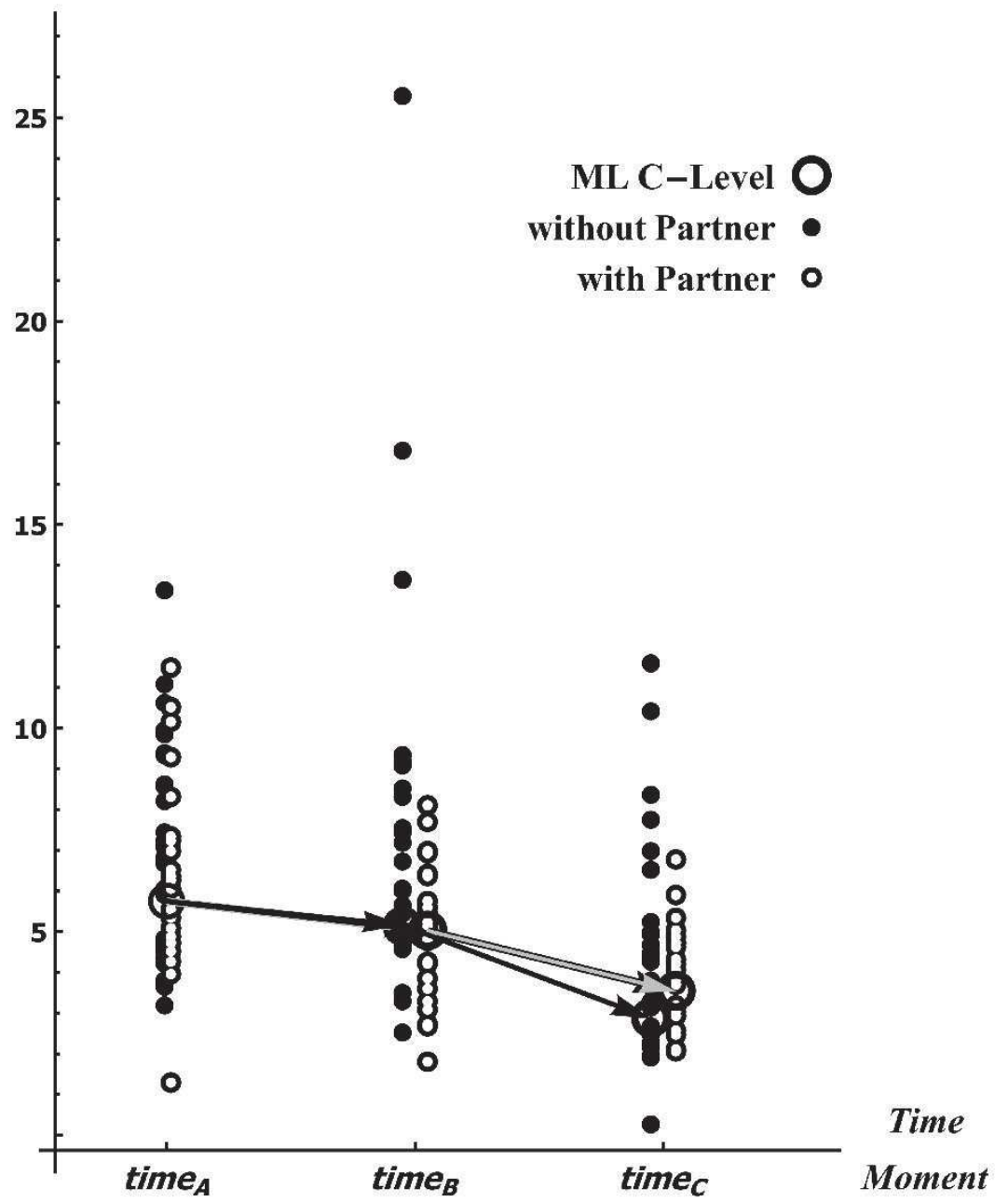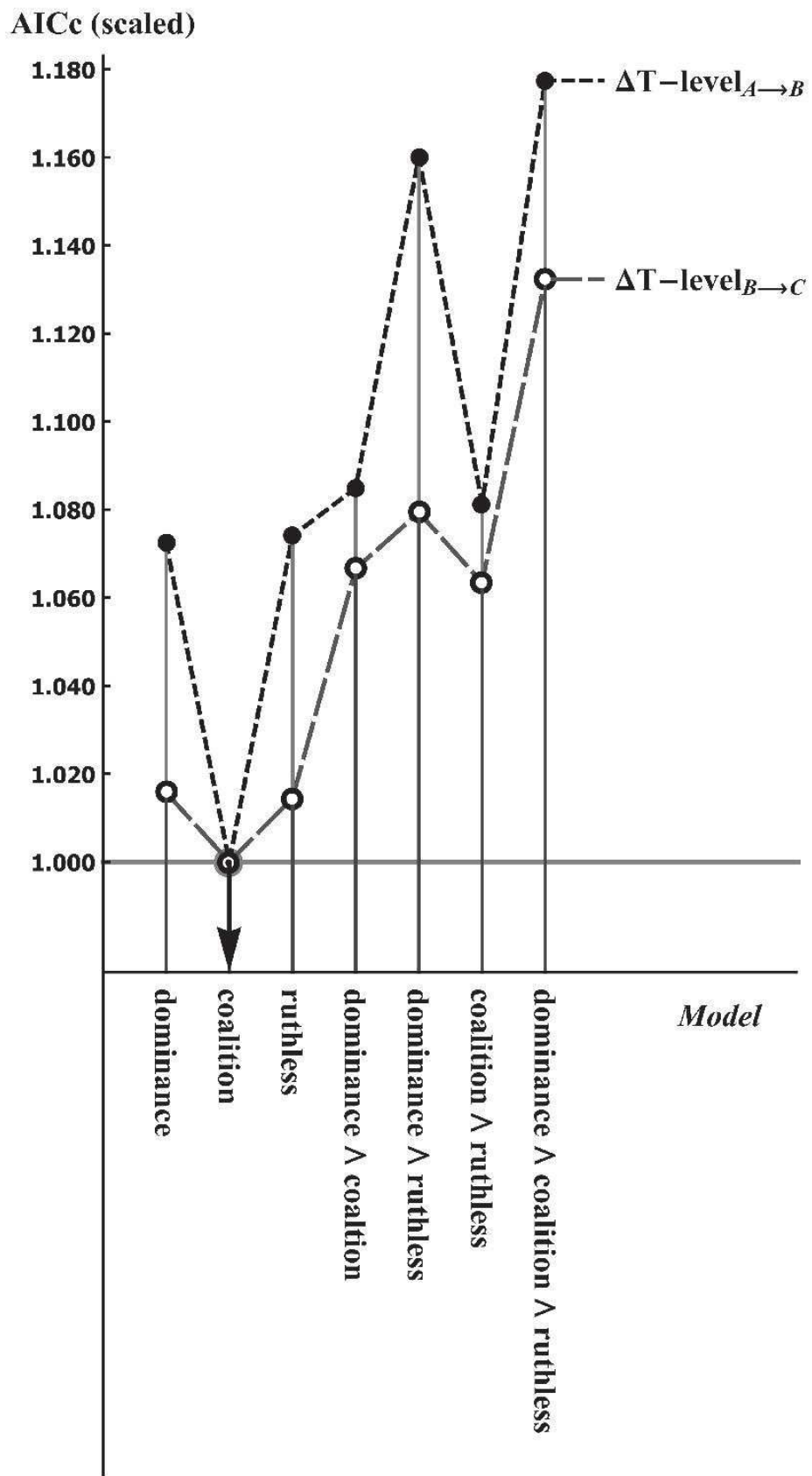
Chapter 5

Klapilová, K., Brody, S., Krejčová, L., Husárová, B. & **Binter, J.** (2015). **Sexual satisfaction, sexual compatibility, and relationship adjustment in couples: the role of sexual behaviors, orgasm and men's discernment of women's intercourse orgasm**. *Journal of Sexual Medicine, 12(3),* 667 – 675.

ORIGINAL RESEARCH—COUPLES

Sexual Satisfaction, Sexual Compatibility, and Relationship Adjustment in Couples: The Role of Sexual Behaviors, Orgasm, and Men's Discernment of Women's Intercourse Orgasm

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ABSTRACT

Introduction. Research indicated that (i) vaginal orgasm consistency is associated with indices of psychological, intimate relationship, and physiological functioning, and (ii) masturbation is adversely associated with some such measures.

Aim. The aim of this study was to examine the association of various dyadic and masturbation behavior frequencies and percentage of female orgasms during these activities with: (i) measures of dyadic adjustment; (ii) sexual satisfaction; and (iii) compatibility perceived by both partners.

Methods. In a sample of 85 Czech long-term couples (aged 20–40; mean relationship length 5.4 years), both partners provided details of recent sexual behaviors and completed sexual satisfaction, Spanier dyadic adjustment, and Hurlbert sexual compatibility measures. Multiple regression analyses were used.

Main Outcome Measure. The association of sexual behaviors with dyadic adjustment, sexual compatibility, and satisfaction was analyzed.

Results. In multivariate analyses, women's dyadic adjustment is independently predicted by greater vaginal orgasm consistency and lower frequency of women's masturbation. For both sexes, sexual compatibility was independently predicted by higher frequency of penile–vaginal intercourse and greater vaginal orgasm consistency. Women's sexual satisfaction score was significantly predicted by greater vaginal orgasm consistency, frequency of partner genital stimulation, and negatively with masturbation. Men's sexual satisfaction score was significantly predicted by greater intercourse frequency and any vaginal orgasm of their female partners. Concordance of partner vaginal orgasm consistency estimates was associated with greater dyadic adjustment.

Conclusions. The findings suggest that specifically penile–vaginal intercourse frequency and vaginal orgasm consistency are associated with indices of greater intimate relationship adjustment, satisfaction, and compatibility of both partners, and that women's masturbation is independently inversely associated with measures of dyadic and personal function. Results are discussed in light of previous research and an evolutionary theory of vaginal orgasm. **Klapilov K, Brody S, Krejčov L, Hus rov B, and Binter J. Sexual satisfaction, sexual compatibility, and relationship adjustment in couples: The role of sexual behaviors, orgasm, and men's discernment of women's intercourse orgasm. J Sex Med 2015;12:667–675.**

Key Words. Sexual Satisfaction; Vaginal Orgasm; Masturbation; Sexual Compatibility; Dyadic Adjustment; Relationship Satisfaction; Sexual Intercourse

Introduction

Understanding the factors, including various sexual behaviors, that are associated positively and negatively with sexual satisfaction, sexual compatibility, and relationship adjustment in couples is of obvious importance for sexual medicine and for couples therapy. In various international studies (including both large nationally representative surveys as well as convenience samples), satisfaction with one's sex life (and in some studies, satisfaction with intimate relationships, life in general, and personal mental health) was robustly positively associated with greater frequency of penile–vaginal intercourse (PVI), and in some studies, inversely associated with masturbation frequency [1–6]. Masturbation was inversely associated with sexual satisfaction and function [7–10].

Similar results were obtained for studies of orgasm triggers: orgasm triggered directly by PVI *per se* (in the case of women, this is termed vaginal orgasm) was associated positively with satisfaction measures and other indices of favorable psychological and psychophysiological function [1,3,6,10–19]. For example, postorgasmic prolactin increases after intercourse are strongly associated with women's assessment of orgasm quality and women's subsequent sexual satisfaction [20], and for both sexes, the postorgasmic prolactin increases following PVI orgasm are severalfold greater than following masturbation [21].

Although echographic studies have found that there might be some activation of the clitoral root during intercourse, it is important to note that vaginal orgasm consistency (VOC) is associated with greater sexual arousability from deep vaginal stimulation but not with sexual arousability from the clitoris or even from the shallow region of the vagina [22]. More importantly, different peripheral nerves are activated by vaginal–cervical stimulation as compared with clitoral stimulation, and this is reflected in activation of different regions of the brain [23,24]. In addition to clinical and neurophysiological issues relevant to sexual behavior differences in satisfaction and relationship function, there are implications for evolutionary theory. It has been proposed [25,26] that presence and frequency of orgasms triggered by sexual intercourse *per se* are more rewarding than other orgasm triggers because of increasing the likelihood of repeat engagement in the one potentially reproductive sexual activity with the same male partner, and thus contributes to the quality of long-term pair

bonding between men and women. Moreover, women's orgasm triggered directly by coitus is considered to be an indicator of fitness (i.e., a phenotypic trait that enhances an individual's ability to propagate his or her genes, including traits that optimize the reproductive fitness of offspring) of both partners [25–27].

Previous studies relied on reports of individuals, but the present study augments the existing research by examining both members of stable heterosexual couples with regard to sexual behaviors (including orgasm triggers) and their associations with sexual satisfaction, sexual compatibility, and dyadic adjustment. In addition, the predictors of concordance of VOC estimates from the partners will also be examined (because of the hypotheses that in better relationships, there will not only be greater PVI frequency and greater vaginal orgasm likelihood, but also that the man will be more aware of, and responsive to, his partner's real vaginal orgasm). Ages of both partners and relationship length will also be examined as possible correlates of the outcomes of interest noted above.

Materials and Methods

The sample consisted of 86 long-term cohabiting couples who participated in the semi-longitudinal Intimate Behavior in Cohabiting Couples Project during the years 2005–2008. All couples were together more than 2 years, were living together more than 1 year, had no children, were aged 18–40 years, and were Czech citizens living in Prague at the time of study. Twenty couples were married (for a detailed description of recruitment criteria and research procedure, see Havlicek et al. [28]). The choice of recruitment criteria (e.g., minimum length of relationship, no children, no sexual dysfunctions or reproductive impairments) reflects our efforts to reduce the influence of important intervening or confounding variables that could lead to data noise. For example, the variable of living with a sexual partner has been found to be an important issue in examining associations between cardiovascular autonomic tone and intercourse frequency [29], and even in clinical trials of pharmacological interventions to increase intercourse frequency [30]. Both partners completed (separately, in private, in Czech language) the Dyadic Adjustment Scale (DAS) [31] (reliability = 0.96) and the Hurlbert Index of Sexual Compatibility (HISC) [32] (reliability = 0.844), and

provided details of days in the past month of various sexual behaviors and corresponding orgasms (see below).

The DAS was used to assess dyadic adjustment. It consists of 32 items loading on four factors: dyadic consensus (13 items), affectional expression (4 items), dyadic satisfaction (10 items), and dyadic cohesion (5 items). Respondents used five-point Likert-type scales for the majority of items (and yes/no binary response for two items). Possible scores can range from 0 to 151, with higher scores indicating better dyadic adjustment (the details of scoring are described in Spanier [31]). The Czech translation of the Spanier dyadic adjustment scale has not been the subject of a formal translation validation, but it is widely used by Czech couples therapists and features in the key Czech textbook on the subject [33].

The HISC consists of 25 items and assesses compatibility and satisfaction in dyadic sexual activities. Sexual compatibility is defined as similarities in the emotional, cognitive, and behavioral components of a sexual relationship, and is significantly correlated with sexual satisfaction [34]. Items (e.g., "I think my partner understands me sexually") are scored on five-point rating scales ranging from 0 (all of the time) to 4 (never). Scores range from 0 to 100, with higher scores indicating greater sexual compatibility.

Sexual behavior items focused on frequency of sexual behaviors, specifically on masturbation, PVI, and dyadic genital sexual activities other than PVI (e.g., oral sex, partner masturbation), all assessed on scales ranging from 0 = never or once a year to 4 = once or more times per day. Within each activity, the percentage of occasions when the activity leads to respondents' orgasm and to orgasm of the partner was assessed. Moreover, sexual satisfaction was rated on a seven-point Likert-type scale (1 = not at all satisfied, 7 = absolutely satisfied). For women, details of orgasmic triggers were assessed (no orgasm, only triggered by direct clitoral stimulation, only triggered by vaginal stimulation, vaginal and direct clitoral stimulation).

The study was conducted in accordance with the principles of the Helsinki Declaration and approved by the institutional review board of Charles University, Faculty of Sciences.

Statistical Analyses

The sample size has more than 80% statistical power to detect a correlation of 0.37 (the medium-to-large effect size correlation obtained between VOC and a personality trait reported in a *JSM* study [12]).

SPSS for Windows version 13.0 (SPSS, Inc., Chicago, IL, USA) was used for analyses. In reporting the results of bivariate analyses, *t* values were converted to r values for simpler comparison of effect sizes. Multiple regression models (using the backward removal method for a balance of statistical power and stability) were used for multivariate analyses. Candidate predictors for the multivariate analyses of both partners' Spanier dyadic adjustment, Hurlbert sexual compatibility, and sexual satisfaction scores were age, partner age, relationship length, women's reports of PVI frequency, women's reports of frequency of partner genital stimulation other than PVI (e.g., partner masturbation, oral sex), masturbation frequency, women's reports of VOC (percentage of PVI occasions resulting in orgasm), a dichotomous variable indicating if the woman had any vaginal orgasm, and both partners' orgasms from partner genital stimulation other than PVI (henceforth, "noncoital orgasm frequency"). Because of the sizable correlations between men's and women's reports of joint sexual behavior, only women's reports were used for the specified variables above (to prevent collinearity problems in the multivariate analyses).

To examine the correlates of concordance of women's reports of VOC and men's estimates of their partners' VOC, men's estimates were regressed onto women's estimates, and the standardized residual was then used as the dependent variable in a multiple regression with the candidate predictors Spanier dyadic adjustment, Hurlbert sexual compatibility, age, partner age, and relationship length.

Results

Table 1 provides a summary of age, dyadic, and sexual characteristics of the 86 couples. When compared with data from a large nationally representative sample of the adult Czech population used for some previous *JSM* papers [10,35], our sample of persons aged 20–40 in stable relationships was of course younger and more likely to be in a stable relationship. When the nationally representative sample was restricted to persons aged 20–40 in stable relationships (this matches for age range, but our sample mean age was a bit younger than in the representative sample), our sample was found to have a similar PVI frequency, lower masturbation

Table 1 Demographics and sexual behavior in the past month for the total sample

Total sample	Female partners	Male partners
Age (years, mean)*	26.5 (3.7)	27.6 (4.3)
Relationship length (years, mean)*	5.4 (2.1)	
PVI frequency (median)[†]	3	3
Partner noncoital activities frequency (median)[†]	2	2
Masturbation frequency (median)[†]	1	2
VOC (%)	64	
Vaginal orgasm (any, %)	64	
Noncoital orgasm frequency (%)	41	
Masturbation orgasm (%)	80	
Hurlbert sexual compatibility*	75.2 (11.2)	73 (9.4)
Spanier dyadic adjustment*	125.7 (9.8)	122.5 (11.1)
Satisfaction with sexual life*	5.4 (1.3)	5.2 (1.2)

*Mean (standard deviation)
[†]Rated on scale: 0 = never or max once a year; 1 = several times a year, max once a month; 2 = several times a month, max once a week; 3 = two times a week or more; 4 = daily or more than once a day
PVI = penile–vaginal intercourse; VOC = vaginal orgasm capacity

frequency, and lower lifetime prevalence of vaginal orgasm (64% vs. 82%). When the Spanier dyadic adjustment scores were compared with the means observed in Spanier's original sample [31], both men and women in our sample had greater dyadic adjustment scores (men: $t = 3.7571$, $P = 0.0002$; women $t = 5.3807$, $P < 0.0001$).

Table 2 provides bivariate associations of ages, relationship length, sexual compatibility, dyadic adjustment, and sexual satisfaction with: any vaginal orgasm, VOC, PVI frequency, frequency of dyadic genital activities other than PVI, non-coital orgasm frequency, and masturbation frequency. In bivariate analyses, women's dyadic sexual compatibility was associated with PVI frequency, VOC, and with having any vaginal orgasm; men's dyadic sexual compatibility was associated with PVI frequency, VOC estimated by women, and male estimate of partner's VOC. Women's dyadic adjustment was associated with having any vaginal orgasm, PVI frequency, and negatively with masturbation frequency; men's dyadic adjustment was not associated with any sexual measure. Both women's and men's sexual satisfaction were associated with having any vaginal orgasm, frequency of dyadic genital activities other than PVI, PVI frequency, and VOC.

In multiple regression analyses, women's Spanier dyadic adjustment was significantly (multiple $R = 0.44$) predicted by VOC (beta = 0.34, $P = 0.001$) and negatively by frequency of masturbation (beta = −0.25, $P = 0.02$). Men's Spanier dyadic adjustment was significantly (multiple

Table 2 Bivariate correlations

		Any VO* woman	Frequency partner stimulation of genital except PVI	% orgasm partner genital except PVI	Frequency PVI woman estimate	VOC woman	Frequency masturbation woman	% VOC man estimate	Frequency masturbation man
Relationship length	r	−0.173	−0.001	0.039	**−0.248**	0.010	0.107	−0.062	−0.030
	P	0.117	0.993	0.731	**0.026**	0.932	0.340	0.589	0.792
Female partners									
Age (woman)	r	−0.211	**−0.363**	−0.069	**−0.219**	0.044	0.136	−0.112	0.074
	P	0.052	**0.001**	0.537	**0.047**	0.693	0.218	0.318	0.507
Relationship adjustment	r	**0.240**	−0.029	0.106	0.126	**0.361**	**−0.272**	0.009	0.092
	P	**0.026**	0.794	0.338	0.257	**0.001**	**0.012**	0.939	0.412
Sexual compatibility	r	**0.401**	0.201	0.173	**0.339**	**0.333**	−0.117	0.168	0.078
	P	**<0.001**	0.068	0.121	**0.002**	**0.002**	0.293	0.136	0.494
Satisfaction in sex life	r	**0.324**	**0.297**	0.067	**0.421**	**0.261**	−0.168	**0.225**	0.058
	P	**0.003**	**0.006**	0.547	**<0.001**	**0.017**	0.128	**0.043**	0.604
Male partners									
Age (man)	r	−0.186	**−0.360**	**−0.224**	**−0.310**	0.024	0.007	−0.024	−0.132
	P	0.089	**0.001**	**0.043**	**0.005**	0.834	0.947	0.830	0.240
Relationship adjustment	r	0.097	−0.039	−0.020	0.032	0.175	−0.147	−0.103	0.074
	P	0.372	0.722	0.855	0.777	0.113	0.183	0.355	0.512
Sexual compatibility	r	0.196	0.210	0.025	**0.484**	**0.325**	−0.012	**0.238**	−0.023
	P	0.077	0.060	0.823	**<0.001**	**0.003**	0.912	**0.035**	0.844
Satisfaction in sex life	r	**0.344**	**0.282**	−0.108	**0.435**	**0.246**	−0.134	**0.310**	0.005
	P	**0.002**	**0.012**	0.347	**<0.001**	**0.029**	0.238	**0.005**	0.964

*t Values converted to r for comparison with other correlations
boldface = $P < 0.05$; relationship adjustment = Spanier dyadic adjustment; sexual compatibility = Hurlbert sexual compatibility
PVI = penile–vaginal intercourse; VO = vaginal orgasm; VOC = vaginal orgasm consistency

R = 0.36) predicted by men's older age (beta = 0.37, $P = 0.009$) and women's younger age (beta = −0.36, $P = 0.012$).

In multiple regression analyses, women's Hurlbert sexual compatibility score was significantly (multiple R = 0.63) predicted by: VOC (beta = 0.37, $P = 0.006$), PVI frequency (beta = 0.29, $P = 0.027$), and inversely with masturbation frequency (beta = −0.31, $P = 0.012$). Men's Hurlbert sexual compatibility score was significantly (multiple R = 0.59) predicted by PVI frequency (beta = 0.43, $P < 0.001$), noncoital genital stimulation frequency (beta = 0.20, $P = 0.04$), and VOC (beta = 0.25, $P = 0.016$).

In multiple regression analyses, women's sexual satisfaction score was significantly predicted (multiple R = 0.58) by: having any vaginal orgasm (beta = 0.23, $P = 0.022$), PVI frequency (beta = 0.34, $P = 0.001$), and noncoital genital stimulation frequency (beta = 0.28, $P = 0.005$). Men's sexual satisfaction score was significantly (multiple R = 0.57) predicted by PVI frequency (beta = 0.35, $P = 0.001$), noncoital genital stimulation frequency (beta = 0.24, $P = 0.015$), and the woman having any vaginal orgasm (beta = 0.29, $P = 0.005$).

Men were asked to estimate their partner's VOC, and this estimate correlated ($r = 0.59$, $P < 0.001$) with the women's reports. The residual from this regression was then used as the dependent variable in a multiple regression that sought predictors of greater concordance of VOC estimates provided by the partners. The one significant predictor of better concordance was Spanier dyadic adjustment (beta = 0.41, $P < 0.001$). This analysis did not include VOC among the candidate predictors; doing so (a debatable statistical approach) resulted in woman's VOC estimate being a highly significant predictor (beta = 0.75, $P < 0.001$) and reducing the Spanier dyadic adjustment predictive power (beta = 0.17, $P = 0.017$). All Spanier subscales were significantly correlated with the residual from the regression, but all had nominally smaller correlations with concordance than did the total score.

For all multiple regression analyses, we inspected plots of the standardized residuals against the regression standardized predicted value, and found them to be properly homoscedastic. The z values for standardized skewness were <2 for all variables. Substituting square-root transformed predictor variables in the multiple regressions did not significantly alter the findings (data not shown). The observed statistical power in all but one of the final multiple regression models was >0.98 (it was

>0.89 for Men's Spanier dyadic adjustment, the one analysis for which only age and not sexual behavior was a significant predictor).

In the final interview with participants, we asked participants to specify any special issues or situations during the last 2 months that could have interfered with sexual frequencies or functioning, and none of the subjects reported any such issues.

Discussion

Overall, for both sexes, sexual satisfaction, dyadic adjustment, and sexual compatibility were associated with greater VOC and greater frequency of PVI (as differentiated from other sexual activities). Women's Spanier dyadic adjustment and sexual compatibility scores were also negatively associated with women's masturbation (in multivariate analyses controlling for other sexual behavior frequencies; thus, the masturbation effect is not due simply to a lack of intercourse). In some analyses, there were adverse effects of greater relationship length (however, men's greater dyadic adjustment was associated with older man's age and younger woman's age) and favorable correlates of partner genital stimulation for women (but no correlation with orgasm from such activities, implying a foreplay effect only). Unlike in a large nationally representative study of individuals that found that male masturbation was associated with poorer satisfaction in multiple realms [2], in the present study, male masturbation was uncorrelated with the outcome measures.

Concordance of men's and women's estimates of VOC was associated with women's Spanier dyadic adjustment score, suggesting that men being more conscious of women's VOC is a marker for women's dyadic adjustment. This dyadic adjustment finding is generally consistent with the finding that women faking orgasm is associated with poorer sexual function [36] and relationship dissatisfaction [37]. Men's discernment of VOC being associated with women's better dyadic adjustment might be explained at least in part by better relationship functioning including the aspects (measured by the scale) of cohesion, affectional expression, and dyadic consensus, which can lead to greater empathy between partners and thus lower percentage of faking orgasms by the woman. Men's ability to discern VOC could be an advantageous trait that contributes to women's relationship and sexual satisfaction, in addition to VOC itself, PVI frequency, and male partner physical traits including male attractiveness, masculinity,

and penis length [15,25,27,35,38–40]. In addition, given that VOC is associated with aspects of women's fitness [1,11,12,18,26,41], men's discernment of VOC provides him with information on partner fitness as well.

The association of measures of better relationship function and sexual satisfaction with specifically PVI frequency (as opposed to frequency of other sexual behaviors) is consistent with the literature on psychological and psychophysiological differences between sexual behaviors [1–3,5,6,15,29,42–45]. Similarly, the association of measures of better relationship function and satisfaction with specifically VOC (as opposed to other triggers of women's orgasm) is consistent with the literature on psychological and psychophysiological differences between sexual behaviors [1,3,6,10–19,46–52]. Even the original Kinsey data revealed that "marital happiness" was associated with female coital orgasm [53]. The association of women's masturbation with poorer function is also consistent with previous intimate relationship and psychophysiological research (including in studies controlling for other sexual behaviors) [1–3,10,44]. It is likely that rather than enhancing sexual function, masturbation might undermine PVI and intimate relationship quality [1,3,47,49]. Higher masturbation frequency could also indicate that the sexual contact with her partner is unsatisfactory for her. Previous research [3] indicated that women's masturbation is associated with less love for her partner (as effect and/or cause). This resonates with the previous finding that lesser Spanier dyadic adjustment is found among women but not men who reported extra-pair sex [28].

A recent JSM paper [54] discussed the opinions of some experts regarding ethical aspects of sexual health care professionals selling vibrators to patients. In the present study, there was no specific inquiry regarding use of vibrators for masturbation. It is noteworthy with regard to the present findings that (i) disturbances of attachment are associated with both lesser VOC and higher frequency of vibrator orgasm [17]; (ii) that immature psychological defense mechanisms (associated with a broad range of psychopathology) are associated with both vibrator use [16] and lesser VOC [12,14,16,55]; and (iii) that unlike some other sexual behaviors including PVI frequency that were significantly associated with greater tactile sensitivity, frequency of vibrator use showed a nonsignificant trend toward being with lesser tactile sensitivity [56].

Instead of partners having very different sources of sexual satisfaction, sexual compatibility, and adjustment, the similarity of the correlates for men and women in a stable couple was striking (similar similarities for men and women were noted in a large nationally representative study of people who were not studied as couples [2]). The one noteworthy difference (other than those discussed above) was that for men, only men's greater age (perhaps reflecting experience or maturity) and women's younger age, but no sexual behaviors, were associated with men's greater Spanier dyadic adjustment score.

For women, the favorable effects of VOC and the adverse effects of masturbation and relationship length were present. The result points to the special importance of PVI, not only in connection with orgasmic experience, but also in women's perception of relationship functioning. This is consistent with the evolutionary-based explanations of the ultimate function of vaginal orgasm as an adaptation evolved to maintain interest in valuable long-term mates [25,26]. Moreover, the fact that women's sexual satisfaction and sexual compatibility were associated with VOC speaks to the special role that vaginal orgasm (as distinct from other orgasm triggers) has in maintaining higher quality intimate relationships. This concept is consistent with earlier findings that both VOC and simultaneous orgasm (men who had orgasm from PVI during the woman's vaginal orgasm) are associated with sexual, life, own mental health, and relationship satisfaction [15,50]. At a theoretical level, these findings are consistent with the above-mentioned evolutionary theory of vaginal orgasm [25,26]. Together with the inverse association of satisfaction with masturbation frequency, our study provides indirect evidence for orgasm during PVI having different characteristics and perhaps different ultimate functions from masturbatory and noncoital orgasm. These results are consistent with other psychological and psychophysiological studies [1,18,22,25].

In addition to the intimate relationship, pair-bonding, and individual strengths discussed in the evolutionary theory, there is also the previous finding that lower Spanier dyadic adjustment is found among women but not men who reported extra-pair sex [28]; this resonates with the present finding that women's but not men's Spanier dyadic adjustment is associated with VOC. In addition to vaginal orgasm being a vehicle for strengthening intimate relationships, it might be the result of a pathway involving awareness of the vagina as a

source of women's orgasm [22,57], a lack of emotional impediments to vaginal orgasm [1,11–14,16,17,52,58,59], focusing attention on vaginal sensations during PVI [57], favorable male partner sexual characteristics [25,35,40,57], and the favorable partnership characteristics noted previously.

However, prenatal [55] and other physiological factors [60] might also influence VOC. A shortcoming of the study is that it involved a convenience sample of relatively modest size, as opposed to a large nationally representative sample. We expect that couples who volunteered to participate in the longitudinal study of relationships (in which the present study was embedded) were less likely than average to have serious relationship problems, and this expectation was consistent with the mean Spanier dyadic adjustment scores being better than in Spanier's original sample [31]. Our sample's scores were all but in one case in the non-dysfunctional range. This restriction of range could conceivably have led to shrinkage of the observed associations. Future research should also include dysfunctional couples to increase the variance in dyadic adjustment scores. The observed lower masturbation rate (compared with Czech nationally representative results) is also consistent with the present sample's better Spanier dyadic adjustment scores. The lower vaginal orgasm rate in our sample might be due to our sample being of younger mean age than the age-range-matched subsample from the Czech nationally representative sample [10,35], given that a nationally representative sample of older Czech women yields even greater vaginal orgasm prevalence [15].

The use of ranges for sexual behavior (but not orgasm) frequencies (rather than a continuous measure) might have resulted in an underestimate of the observed associations. The choice of the specific sample of a relatively young heterosexual cohort without children could lead one to be relatively modest regarding generalization of the results. Future studies should employ large nationally representative samples, while examining the specific effects of additional variables including marital status, presence of children, and length of relationship.

However, our stringent recruitment criteria (regarding relationship length, sexual orientation, no diagnosed sexual and fertility issues, living together, no children) can also be seen as among the strengths of this study, because it allowed us to avoid the influence of important intervening variables that could exacerbate data noise and lead to underestimation of the observed associations.

Other strengths of the study include measuring (separately) both partners in stable couples, use of a community (rather than only student) sample, using multiple measures of satisfaction and relationship function, using clearly differentiated sexual behaviors and orgasm triggers, and examining for the first time the correlates of men's concordance with women's estimates of VOC.

Conclusions

The findings provide further support for PVI frequency and VOC having key roles in better dyadic adjustment, dyadic compatibility, and women's greater sexual satisfaction. In contrast, women's masturbation is associated with poorer general and intimate relationship quality. Young women should be made aware of the vagina being a source of women's orgasm and made aware of differences between sexual behaviors.

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by: literature review, design, data collection, data preparation and cleaning, data analyses, manuscript preparation

2. *"Sexual Satisfaction, Sexual Compatibility, and RelationshipAdjustment in Couples: The Role of Sexual Behaviors, Orgasm, and Men's Discernment of Women's Intercourse Orgasm"*

by: study design and data collection

3. *"Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition"*

by: literature review, design, data collection, data preparation and cleaning, manuscript preparation

4. *"Vocal modulation during courtship increases proceptivity even in naïve listeners"*

by: data collection, result interpretation, manuscript revisions

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Sao Paulo, 20th of July 2016

Approval of co-authorship and agreement with use of the publication as a part of

Ph.D. thesis of Jakub Binter

I, Jaroslava Varella Valentova, Ph.D., confirm that Jakub Binter participated on study design, data collection and manuscript elaboration of the following publication:

Binter, J., Leongómez, J. D., Moyano, N., Valentová, J., & Klapilova, K. (2012). Sex differences in the incidence of sexual fantasies focused on evolutionary relevant objects, *Anthropologie, 50,* **1, 83-93.**

I agree that the candidate can use this publication as a part of his Ph.D. thesis.

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I Juan David Leongómez am informed and agree that Jakub Binter will use the articles *"Vocal modulation during courtship increases proceptivity even in naïve listeners"*, *"Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition for a Desired Partner"* and *"Sex differences in the incidence of sexual fantasies focused on evolutionary relevant objects"* as part of his Ph.D. thesis.

In: Bogotá, Colombia   Date: 21 April 21, 2017   Signature:

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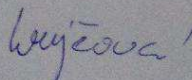
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I Lucie Krejčová am informed and agree that Jakub Binter will use the articles *"Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition"* and „*Sexual Satisfaction, Sexual Compatibility, and Relationship Adjustment in Couples: The Role of Sexual Behaviors, Orgasm, and Men's Discernment of Women's Intercourse Orgasm"* as part of his Ph.D. thesis.

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I Klára Bártová am informed and agree that Jakub Binter will use the articles *"Single and Partnered Young-Adult Men React with Different Changes in both Testosterone and Cortisol Levels during Virtual Competition"* **as** part of his Ph.D. thesis.

In: *Prague* Date: 20.4. 2017   Signature: *[signature]*