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ORIGINAL PAPER

Factors Influencing Sexual Vocalization in Human Females

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Abstract
Human females use numerous signals to attract male attention which can be ultimately motivated by enhanced paternal investment in the offspring. Sexual vocalization is a form of female sexual signaling. The majority of hypotheses attempting to explain the functional significance of vocalizations have been applied on non-human primates, while research on human females is scarce. This study investigated factors underlying sexual vocalization with a sample of 403 heterosexual Slovak females. Sexual vocalization was most frequent during penetration itself compared with other forms of sexual activities, which supports its signaling function. The most frequently reported sexual vocalizations were moaning/groaning, followed by screams and instructional commands, squeals, and words. Both the frequency and intensity of sexual vocalizations were significantly and positively associated with sexual arousal during the last sexual vaginal intercourse and sociosexuality. About 38% of females reported that they pretended vocalization and, in turn, pretended vocalization was exclusively associated with pretending orgasm. No direct evidence was found for any associations between self-reported frequency and intensity of sexual vocalization and partner satisfaction/physical attractiveness/ambition/dominance, self-perceived attractiveness, or occurrence of orgasm. The frequency (but not intensity) of sexual vocalization was positively influenced by the conception risk. On the proximate level, it seems that sexually less restricted females may use sexual vocalization to increase their sexual attractiveness to their current partner by means of boosting their partner's self-esteem. Enhanced vocalization by sexually unrestricted females may ultimately secure higher paternal investment and increase the confidence of the paternity of current sexual partner.

Keywords Female attractiveness · Human evolution · Female orgasm · Sociosexuality

Introduction

In 95% of mammals, females invest more in parental care than males (Clutton-Brock, 1991). Sexual differences in parental care ultimately influence female choosiness and male-male competition over females (Trivers, 1972). Human females also invest more in intra-uterine development and post-natal offspring gestation and nursing than males in all known societies (Eibl-Eibesfeldt, 1989; Geary, 2000; Hewlett, 1992). Human males, however, are exceptional among primates, because males often invest in their offspring beyond the initial investment of gametes (Clutton-Brock, 1989; Geary, 2000). Paternal investment could be favored by means of a reduced child mortality (Alonso & Ortiz-Rodríguez, 2017; Daly & Wilson, 1988). This investment constitutes the basis for female competition over males (Puts, 2010; Stockley & Bro-Jørgensen, 2011).

Human females use numerous signals to attract male attention (Gangestad & Thornhill, 2008; Miller, 2000). If females are interested in mating, for example, then interactions with males other than their primary partner are increased (Bellis & Baker, 1990; Gangestad et al., 2002; Jones et al., 2005), and females dress more provocatively (Grammer et al., 2004; Haselton et al., 2007) and wear red-colored dresses which are more sexually attractive to males than other colors (Eisenbruch et al., 2015; Elliot et al., 2013; Prokop & Hromada, 2013), report more flirtatious behavior (Haselton & Gangestad, 2006), are more receptive to men's courtship invitations (Guéguen, 2009), and engage in various forms of beautification (Guéguen, 2012). As all these signals are attractive to males, females who possess these characteristics have an

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advantage in attracting mates (Buss, 1996). These signals can be faked, however, which creates the ground for an arms race between the sexes. The battle between the sexes continues by favoring male counteradaptations to such signal manipulation (Borgerhoff-Mulder & Rauch, 2009).

Female sexual vocalization is sexually attractive to males of both humans (Brewer & Hendrie, 2011; Younis & Ibrahim, 2015) as well as non-human primates (Semple, 1998; Semple & McComb, 2000), suggesting that it is a form of sexual signalization. Considering non-human primates, sexual vocalization is more common in promiscuous primates who advertise their receptivity with sexual swellings (Dixson, 1998; Pradhan et al., 2006). Some evidence shows that sexual vocalization is enhanced in females at the peak of fertility (e.g., Aujard et al., 1998; Pfefferle et al., 2008, but see Bernaldo de Quirós et al., 2018 and references therein). These explanations are proximate (concerned with how it works). Complementary to the former, ultimate explanations are concerned with why a behavior exists. Evidence suggests that vocalization promotes male-male competition or sperm competition which can ultimately increase offspring quality (Gerloff et al., 1999; Kano, 1992; Pfefferle et al., 2008; Townsend et al., 2008), or to confuse paternity and reduce risk of infanticide (Furuichi, 1989). Indeed, more promiscuous females use copulatory calls more than monogamous females (Maestripieri et al., 2005) and copulations with socially dominant males are accompanied by more frequent copulatory calls than copulations with a subordinate male (Clay et al., 2011; Nikitopoulos et al., 2004; O'Connell & Cowlishaw, 1994; Semple et al., 2002; Townsend et al., 2008). In humans, male dominance was associated with deeper female orgasms (King & Belsky, 2012) which could act as a female choice mechanism, ultimately aiding females in selecting sperm from preferred mates (Baker & Bellis, 1993).

Although research on sexual vocalization in humans is scarce (Brewer & Hendrie, 2011; Younis & Ibrahim, 2015), some preliminary evidence about its functional significance exists. Sexual vocalization of most human females occurs during penetration rather than during other forms of sexual intercourse (Brewer & Hendrie, 2011; Younis & Ibrahim, 2015) and does not accompany the female's own orgasm, but rather their partner's ejaculation (Brewer & Hendrie, 2011). A significant number of females reported that they use vocalization to facilitate their partner's ejaculation, and/or to boost their enjoyment and self-esteem, or both (Brewer & Hendrie, 2011). The latter argument suggests that sexual vocalization might be associated with pretended orgasms during penetration, which is also motivated by the maintenance of a partner's sexual interest and enhancing mate retention (Kaighobadi et al., 2012; McCoy et al., 2015; Muehlenhard & Shippee, 2010).

This study investigated the functional significance of human sexual vocalization. I hypothesized that the intensity and frequency of sexual vocalization is positively influenced by male quality. In particular, females of non-human primates tend to vocalize more when mating with a more socially dominant male which can be ultimately motivated by direct benefits, namely by getting protection against other males (O'Connell & Cowlishaw, 1994; Todt et al., 1995). This could be also due to genetic benefits of mating with dominant males and/or suppression of vocalizations when mating with subordinate males, as this could draw attention and provoke aggression from dominant males (Townsend et al., 2008). Sexual vocalization would be more frequent and intensive during sexual intercourse with a dominant male (Hypothesis 1). By mating with a good quality male, human females can get further direct benefits in terms of material resources (Fieder et al., 2005) as well as indirect benefits in terms of good-gene indicators (Buss & Shackelford, 2008). Indeed, females report more orgasms when mating with males possessing cues of a high genetic quality (King & Belsky, 2012; Puts et al., 2012; Shackelford et al., 2000; Sherlock et al. 2016; Sela et al., 2015; Thornhill et al., 1995). As a result, sexual intercourse is in all probability more arousing when mating with a male of high quality. I hypothesize that cues of a sexual partner's wealth (Hypothesis 2) and genetic quality (Hypothesis 3) positively correlate with the frequency and intensity of female sexual vocalization. Sexually more arousing vaginal intercourses would be associated with more intense and frequent vocalizations (Hypothesis 4). Female physical attractiveness is a major component of a women's mate value (Buss & Schmitt, 1993; Cloud & Perilloux, 2014; Schmitt, 2014), and high mate value females have elevated standards for cues of good genes and resources (Buss & Shackelford, 2008; Prokop et al., 2020). This would suggest that physically more attractive females produce more intensive and frequent sexual vocalization than their less physically attractive peers. More attractive women, however, should also be more discriminating (Buston & Emlen, 2003; Pawlowski & Dunbar, 1999) which makes a prediction in the opposite direction, and this would result in no relationship at all. I hypothesize that controlling for partner attractiveness, more attractive women should produce less intense and less frequent vocalizations (Hypothesis 5).

If sexual vocalization strengthens the pair bond (Ellsworth & Bailey, 2013; Hamilton & Arrowood, 1978; Wheatley & Puts, 2015), then partner satisfaction should correlate with the frequency and intensity of female sexual vocalization (Hypothesis 6). An alternative to the strengthened pair bond hypothesis is the sire choice hypothesis which suggests that sexual vocalization is a mechanism whereby women increase their chances of conceiving with men of superior genetic quality (Ellsworth & Bailey, 2013; Wheatley & Puts, 2015). High openness to short-term sexual relationships termed

sociosexuality (Simpson & Gangestad, 1991) is associated with a higher sex drive (Ostovich & Sabini, 2004), a higher lifetime number of sexual partners (Lukaszewski et al., 2014; Prokop & Fedor, 2013), and pornography consumption (Prokop, 2015; Zheng & Zheng, 2014). Higher frequency and intensity of sexual vocalization might correlate with sociosexuality (Hypothesis 7), because it can ultimately function to confuse paternity and reduce risk of infanticide (Furuichi, 1989). More frequent sexual vocalizations among promiscuous females in non-human primates (Maestripieri et al., 2005) also provide some support for this possibility. I hypothesize that sexual vocalization of human females is stronger in females in their fertile phase of menstrual cycle similarly as in some non-human primates (e.g., Aujard et al., 1998; Pfefferle et al., 2008) (Hypothesis 8). Finally, sexual vocalization might be associated with pretended orgasms during penetration in order to manipulate partner's behavior (Hypothesis 9).

Method

Participants

A total of 444 Caucasian women participated in the research. Bisexuals ($N = 35$) and lesbians ($N = 6$) were removed from the analyses, restricting the sample to $N = 403$ heterosexual females. All the participants were volunteers and were given extra credit for the human biology class for their participation. The language of the online questionnaire was Slovak.

Measures

Frequency of Sexual Vocalization

Frequency of sexual vocalizations was investigated using categories adopted from Brewer and Hendrie (2011). Specifically, participants were asked how often they did the following noises during their last sexual intercourse on a 7-point scale (1 = never, 7 = always): silence (reverse-scored), moan/groan, scream/shriek/ squeal, words [e.g., partner's name, ''yes'', etc.], instructional commands [e.g., ''more'']) during sex. The reliability of the responses was acceptable (actual Cronbach $\alpha = 0.76$). The summarized scores were used in the statistical analyses. An additional single-item question (Do you use sexual vocalization during each vaginal sexual intercourse?) examined whether sexual vocalization is used exceptionally, or whether it is common during each sexual intercourse. Answers were bipolar (yes or no).

Intensity of Sexual Vocalization

The participants were asked how intense the sexual vocalizations (silence [reverse-scored], moan/groan, scream/shriek/ squeal, words [e.g., partner's name, ''yes'', etc.], instructional commands [e.g., ''more'']) during their last sexual intercourse were. The responses were answered on a 7-point scale (1 = never, 7 = always), and their reliability was acceptable (actual Cronbach $\alpha = 0.79$). The summarized scores were used in the statistical analyses.

Occurrence of Sexual Vocalization

The occurrence of sexual vocalization achieved during the different stages of sexual activity (i.e., during oral sex delivered by the partner, during masturbation by the partner, during penetration itself, and during self-masturbation) was examined by bipolar answers (yes/no) on each type of sexual activity.

Restriction of Vocalization

It is reasonable to suggest that the participants could restrict themselves in sexual vocalizations due to various reasons (e.g., not disturbing other members of the household, etc.). Participants were asked whether they had to restrict their sexual vocalization in their last sexual intercourse and responses were answered on a 7-point scale (1 = absolutely not, 7 = extremely much).

Sociosexuality

Sociosexuality was assessed with the Revised Sociosexual Orientation Inventory (SOI-R; Penke & Asendorpf, 2008). A high SOI-R score indicates unrestricted sociosexual orientation—a propensity to engage in more short-term sexual

Table 1 Demographics and behaviors of participants

	M	Min	Max	*SD*	*N*
Age (years)	20.9	18	43	3.2	403
Length of relationship (months)	29.9	1	300	28.7	344
SOI (summarized score)	25.3	9	72	11.7	403
Partner satisfaction	6.09	1.5	6.1	1.02	403
Partner's physical attractiveness	5.8	2	7	1.1	403
Partner's ambitions	5.8	2	7	0.9	403
Restriction of vocalization	3.4	1	7	2.06	403
Partner's dominance	4.8	1	7	1.2	403
Frequency of orgasms during sex	68.2	0	100	31.7	403
Sexual arousal in last intercourse	5.5	1	7	1.3	403
Self-perceived attractiveness	4.7	1	7	1.3	403

relationships. I summarized the scores from the SOI-R to create an overall sociosexuality index (Table 1) with acceptable reliability (actual Cronbach $\alpha = 0.86$).

Partner Satisfaction

The four-item Partner Satisfaction Scale (PSS, actual Cronbach $\alpha = 0.76$ for heterosexuals who were involved in a sexual relationship, $N = 343$) (Pham et al., 2013) was applied to investigate participants' partner satisfaction. This scale consists of four questions about their relationship satisfaction, being answered on a Likert-type scale ranging from 1 (Not at all) to 7 (Extremely). Example items are: How emotionally satisfied are you with your partner? and How committed are you to your partner? The mean score of the PSS was used in the statistical analyses.

Partner's Physical Attractiveness

Three items derived from Prokop et al. (2015), assessing physical attractiveness with acceptable reliability (actual Cronbach $\alpha = 0.82$ for those involved in a sexual relationship), were used to examine perceived partner physical attractiveness. Example items are: To which degree do you consider the face of your current sexual partner attractive in comparison with other males? To which degree do you consider the body of your current sexual partner attractive in comparison with other males? Responses were answered on a Likert-type scale ranging from 1 (Not at all) to 7 (Extremely).

Partner's Ambition

Current sexual partners' ambition as cues of direct benefits was examined with four items derived from Prokop et al. (2015) with acceptable reliability (actual Cronbach $\alpha = 0.74$ for those involved in a sexual relationship). Example items are: To which degree do you consider the ambition of your current sexual partner in comparison with other males? How do you think your current partner will be financially successful in the future? Responses were answered on a Likert-type scale ranging from 1 (Not at all) to 7 (Extremely).

Partner's Dominance

Perceived partner dominance was examined with a single valid item: To which degree do you consider the dominance of your current sexual partner? Responses were answered on a Likert-type scale ranging from 1 (Absolutely submissive) to 7 (Extremely dominant).

Frequency of Copulatory Orgasms and Sexual Arousal

Participants were asked whether they achieved orgasm during their last vaginal sexual intercourse (276 of 403 [68%] participants responded positively) and how often they achieved copulatory orgasms with their partner using percentage estimates.

Pretended Orgasms and Sexual Vocalizations

Females were asked whether they at least sometimes pretended orgasm (yes or no) and whether they pretended sexual vocalization (never, at least sometimes). Furthermore, females were asked for reasons for pretended sexual vocalization (boost partner's ego, speed up partner's ejaculation, for self-satisfaction, for terminating penetration due to discomfort, pain, time limits, to fill silence or "others"). Answers were assessed with the 7-point Likert-type scale (1 = totally disagree, 7 = absolutely agree).

Measuring Self-Perceived Attractiveness

The participant's self-perceived attractiveness was assessed with the 7-point Likert-type scale ("How physically attractive are you for males?" [1 very unattractive, 3 average, and 7 very attractive]) (Little et al., 2001).

Measuring the Fertile Window

Each female was asked on (1) the actual date, (2) the first day of her last menstrual period, (3) the typical length (in days) of their cycle, and (4) the day of their last vaginal sexual intercourse. Probabilities of conception risk were calculated using the backward method (Gangestad et al., 2016). Daily conception risk data were obtained from Shirazi et al. (2019). Twenty-five women with cycle lengths differing by more than 3 days from a 28-day cycle were eliminated from analysis following Puts (2006).

Procedure

The research was carried out online. Prior to completing the research, each female received an ID code to establish her identity. Each female was initially asked demographic questions (e.g., her age, relationship status [343 of 403 females were involved in a romantic sexual relationship], and relationship length, whether she was currently using contraceptive pills or another form of hormonal contraception (97 of 403, 24%), her sexual orientation and whether she was pregnant (6 of 403 [1.5%] females reported being pregnant), see also Table 1 for a description), then responded to questions and scales.

Statistical Analyses

Occurrence of sexual vocalization (binomial dependent variable) was examined with the Generalized Linear Mixed Model (GLMM). Participant's ID was defined as a random factor to avoid pseudoreplication. The summarized scores on the frequency and intensity of sexual vocalization were Box-Cox transformed to achieve normal distribution. The General Linear Model (GLM) was used to examine differences in the frequency and intensity of sexual vocalizations with respect to the type of sexual activity defined as the within-subject variable. Factors influencing the frequency and intensity of sexual vocalizations (dependent variables) were examined with a multiple linear regression where possible multicollinearity was checked through examining Variance Inflation Factors (VIF) (all VIF < 2.0). Factors influencing pretended vocalization (binomial dependent variable) were examined with multiple logistic regression.

Results

Occurrence of Copulatory Noises

More than half of females (261 of 403, 65%) reported sexual vocalization in each sexual intercourse. GLMM with the presence/absence of vocalization as a binomial dependent variable controlled for participant's ID revealed the significant main effect of the occurrence of vocalization resulting from various sexual behaviors ($F(3, 1528) = 420.69$, $p < 0.001$). Vocalization was most frequently reported during penetration (357/403 females) compared with all other sexual behaviors (analysis of contrasts, all $p < 0.001$). Oral sex delivered by the partner (192/403 females) and masturbation by the partner (174/403 females) occurred at a similar frequency (analysis of contrasts, $p = 0.16$). Vocalization during self-masturbation was the least frequent (38/403 females) compared with other sexual behaviors (analysis of contrasts, all $p < 0.001$).

The most frequently reported sexual vocalizations ($N = 403$ females) were moaning/groaning, followed by screams, instructional commands, squeal, words, and silence (Table 2). The within-subject GLM showed that differences between means were significant ($F(5, 2010 = 152.87$, $p < 0.001$)), and subsequent post hoc analysis (Tukey) revealed that moan/groan vocalization was reported more than any other noise (all $p < 0.001$). The intensity of vocalization ($N = 403$ females) was also different with respect to the variety of noises ($F(5, 2010 = 115.03$, $p < 0.001$)) with moaning/groaning being the most frequently reported noise (Tukey post hoc tests, all $p < 0.001$).

Table 2 Frequency and intensity of sexual vocalizations reported by heterosexual females ($N = 403$)

	Frequency		Intensity	
	M	*SD*	*M*	*SD*
Moaning/groaning	4.63	1.96	4.23	1.72
Screams	3.04	1.99	2.88	1.98
Instructional commands	2.80	1.86	2.66	1.86
Squeal	2.80	1.88	2.54	1.73
Words	2.21	1.72	1.94	1.56
Silence	2.04	1.44	2.63	1.74

Preliminary Analyses of Predictors of Sexual Vocalization

Pearson's zero-order correlation analysis was conducted to ascertain the strength of linear relationships between the continuous predictor variables and the possibility of multicollinearity, which is caused by high intercorrelations among predictor variables in further statistical analyses ($N = 403$ participants, Table 3). Considering at least moderate correlations ($r(401) \sim 0.3$ and more), the degree to which the vocalizations were restricted, self-perceived attractiveness and partner's dominance did not correlate with any variables. SOI negatively correlated with partner satisfaction, physical attractiveness of the partner, and ambitions (Table 3). Partner satisfaction positively correlated with frequency of orgasms, partner's physical attractiveness, ambitions of a partner, and with sexual arousal during the last sexual intercourse (Table 3). Orgasm frequency correlated positively with sexual arousal during the last sexual intercourse (Table 3). The partner's physical attractiveness correlated with his perceived ambitions (Table 3). The length of a romantic sexual relationship (calculated only for those who were involved in a romantic relationship, $N = 344$) only positively correlated with the female's age ($r(401) = 0.55$, $p < 0.001$).

Frequency of Sexual Vocalization

Statistical analysis is restricted to $N = 337$ non-pregnant females involved in a romantic relationship. The model was significant ($F(15, 321) = 7.95$, $p < 0.001$) and explained 27% of the total variance of the results (R^2). The frequency of copulatory noises was significantly and positively associated with sexual arousal during the past sexual vaginal intercourse (Hypothesis 4) and sociosexuality (Hypothesis 7). When the female was forced to narrow her sexual vocalization, then the reported frequency of vocalizations was lower. This finding contributes to the reliability of the research instrument. The association with the frequency of vocalizations in previous sexual intercourses provides some preliminary evidence about the repeatability of sexual vocalization. Self-perceived attractiveness was not associated with the reported frequency of vocalizations, even after controlling

Table 3 Correlation matrix of the predictor variables included in analyses

	Sexual arousal in last intercourse	Partner's dominance	SOI	Partner satisfaction	Frequency of orgasms during sex	Partner's physical attractiveness	Partner's ambitions	Self-perceived attractiveness	Restriction of vocalization
Age	− .017	− .015	.119*	− .093	.029	− .025	.006	− .023	− .051
Sexual arousal in last intercourse		.185***	− .144**	.410***	.322***	.312***	.226***	.166**	.010
Partner's dominance			− .08	.218***	.074	.163**	.176***	.051	− .039
SOI				− .344***	− .023	− .33***	− .299***	.047	− .087
Partner satisfaction					.301***	.467***	.473***	.135**	.009
Frequency of orgasms during sex						.149**	.112*	.145**	− .013
Partner's physical attractiveness							.432***	.116*	.059
Partner's ambitions								.208***	.004
Self-perceived attractiveness									− .007

*$p < .05$, **$p < .01$, ***$p < .001$

Table 4 Multiple regression on frequency of sexual vocalization

Predictor	B	SE of B	β	t	p
Restriction of SV[a]	− 0.035	0.018	− 0.095	− 1.97	.05
Age	− 0.017	0.014	− 0.069	− 1.16	.25
Length of relationship	0.001	0.002	0.034	0.567	.57
Sexual arousal	0.162	0.035	0.254	4.6	< .001
Orgasm in last intercourse	− 0.009	0.103	− 0.005	− 0.09	.93
Partner dominance	0.037	0.032	0.058	1.17	.24
SOI	0.008	0.004	0.125	2.231	.03
Partner satisfaction	0.019	0.014	0.088	1.33	.19
Orgasm frequency	0.0	0.002	0.009	0.15	.88
Pretending orgasms	0.15	0.091	0.083	1.65	.1
SV during each intercourse	0.563	0.079	0.351	7.15	< .001
Partner physical attractiveness	0.047	0.045	0.064	1.05	.3
Partner ambition	− 0.1	0.054	− 0.109	− 1.85	.065
Self-perceived attractiveness	0.035	0.029	0.06	1.2	.23
Hormonal contraceptives	0.076	0.082	0.044	0.92	.36

[a]Sexual vocalization

for partner's attractiveness, ambition, or both. Other variables were not significantly associated with frequency copulatory noises (Table 4).

Intensity of Sexual Vocalization

Statistical analysis is restricted to $N = 337$ non-pregnant females involved in a romantic relationship. The model was significant ($F(15, 321) = 7.32$, $p < 0.001$) and explained 26%

Table 5 Multiple regression on intensity of sexual vocalization

Predictor	B	SE of B	β	t	p
Restriction of SV[a]	−0.013	0.004	−0.177	−3.612	<.001
Age	−0.004	0.003	−0.075	−1.236	.217
Length of relationship	0.0	0.0	0.052	0.864	.39
Sexual arousal	0.035	0.007	0.264	4.729	<.001
Orgasm in last intercourse	0.032	0.021	0.093	1.49	0.14
Partner dominance	0.004	0.007	0.027	0.543	.59
SOI	0.002	0.001	0.113	1.994	.05
Partner satisfaction	0.003	0.003	0.058	0.853	.39
Orgasm frequency	0.0	0.0	−0.091	−1.446	.15
Pretending orgasms	0.019	0.019	0.052	1.014	.31
SV during each intercourse	0.103	0.016	0.311	6.261	<.001
Partner physical attractiveness	0.013	0.009	0.085	1.388	.17
Partner ambition	−0.012	0.011	−0.065	−1.091	.28
Self-perceived attractiveness	0.004	0.006	0.034	0.673	0.50
Hormonal contraceptives	0.023	0.017	0.064	1.325	.19

[a]Sexual vocalization

of the total variance of the results (R^2). Sexual vocalization was significantly and positively associated with arousal during the last sexual vaginal intercourse (Hypothesis 4) and sociosexuality (Hypothesis 7) (Table 5). When the female reported that her sexual vocalization was restricted, then the reported intensity of vocalizations was lower. This finding contributes to the reliability of the research instrument. The association with intensity of vocalizations in previous sexual intercourses provides some preliminary evidence about repeatability of sexual vocalization. Self-perceived attractiveness was not associated with the reported intensity of vocalizations, even after controlling for partner's attractiveness, ambition, or both. Other predictors were not statistically significant (Table 5).

Does Conception Risk the Influence of Sexual Vocalization?

I further restricted participants on a subsample of those who did not take HA, were involved in a romantic relationship, were not pregnant, and provided all requested information necessary for calculating the fertile window ($N = 179$). The same analyses on the intensity and frequency of sexual vocalization as a dependent variable with the predictors listed in Table 4 and 5 yielded similar results as previously. The frequency of sexual vocalization was significantly influenced by the conception risk which was included as a new independent variable to the model (multiple regression, $\beta = 0.16$, $p = 0.02$). The intensity of the sexual vocalization was not influenced by the fertile window (multiple regression, $\beta = -0.009$, $p = 0.90$). Hypothesis 8 was partly supported.

Interestingly, however, the score of sexual arousal during the last sexual intercourse (dependent variable) was higher during the fertile phase of the menstrual cycle (multiple regression, $\beta = 0.15$, $p = 0.03$) which provides some support for the reliability of the estimates of the fertile window. Orgasm frequency and partner satisfaction were further variables which significantly influenced the score of sexual arousal (multiple regression, $\beta = 0.31$ and 0.25, $p = 0.0004$ and 0.01, respectively).

Pretended Vocalization

A total of 153 of 403 (38%) females reported that they pretended vocalization at least once and the remaining 250 reported that they never falsely vocalized during sexual intercourse. Logistic regression with pretended vocalization as a dependent variable and identical independent predictors as in Table 4 showed that pretended vocalization was only associated with pretending orgasm (multiple logistic regression, Wald's $\chi^2 = 19.6$, df = 1, $p < 0.001$). Hypothesis 9 was supported. Other variables remained non-significant (all $p > 0.08$). Indeed, only 36 of 250 females, who never pretended vocalization, reported pretending orgasm at least once, while 64 of 153 females who pretended vocalization also pretended orgasms.

The within-subject GLM revealed the significant main effect of the occurrence of pretended vocalization resulting from various female motivations ($F(5, 760) = 83.97$, $p = 0.0001$). Pretended vocalization was most frequently motivated by the self-satisfaction of the female ($M = 4.33$,

SD = 2.1), followed by the strengthening of the partner's ego (*M* = 4.10, *SD* = 2.01), quickening of the partner's orgasm (*M* = 3.93, *SD* = 2.04), terminating sexual intercourse (*M* = 2.42, *SD* = 1.84), filling silence (*M* = 2.18, *SD* = 1.76), and "others" (*M* = 1.42, *SD* = 1.2).

Discussion

This study aimed to investigate the correlates of sexual vocalization in human females using both proximate and ultimate explanations. Nine hypotheses derived mainly from the current knowledge about sexual vocalization in non-human primates were examined, and some of them received statistical support.

Moaning/groaning was the most common type of reported sexual vocalization reported in the present study. This pattern seems to be cross-culturally universal, considering that similar results were obtained in the UK (Brewer & Hendrie, 2011) and Egypt (Younis & Ibrahim, 2015). In a similar vein, females reported the most frequent and intense sexual vocalization during vaginal penetration rather than during foreplay (Brewer & Hendrie, 2011; this study) or during self-masturbation (this study). The latter argument provides additional support for the idea that sexual vocalization is a sexual signal with a communicatory function rather than an incidental by-product of the sexual act (Hamilton & Arrowood, 1978; Pradhan et al., 2006).

Three hypotheses (Hypothesis 1–3) predicted that sexual vocalization will be correlated with partner's characteristics such as dominance, wealth, and genetic quality. Only a few researchers found associations between the frequency of female copulatory orgasms and the partner's wealth (Gallup et al., 2014; but see Pollet & Nettle, 2010), but the present research could not provide additional support for this idea. At first glance, the present results suggest that female sexual vocalization is highly independent from cues of the partner's quality. Otherwise, both the frequency and intensity of sexual vocalization strongly correlated with sexual arousal in their last sexual intercourse (Hypothesis 4). Sexual arousal was mediated with certain partner's characteristics, because it correlated with orgasm frequency and orgasm frequency correlated (together with sexual arousal) with partner satisfaction (Hypothesis 6). Partner satisfaction, in turn, correlated with partner's physical attractiveness and ambitions of a partner. Correlations between orgasm frequency and male quality corroborate previous findings (Puts et al., 2012; Sela et al., 2015; Shackelford et al., 2000; Sherlock et al., 2016; Thornhill et al., 1995). Thus, sexual arousal is mediated by male quality and significantly influences both the frequency and intensity of female sexual vocalization. Experiencing orgasm was not associated with sexual vocalization, suggesting that this behavior is under conscious control (Brewer & Hendrie, 2011). Females' self-perceived physical attractiveness (Hypothesis 5), on the other hand, seems to be unrelated to female sexual vocalization.

Female sociosexuality significantly correlated with both the frequency and intensity of sexual vocalization (Hypothesis 7). Although no study has investigated this association, there are a number of suspicions, suggesting that this correlation might exist. First, Younis and Ibrahim (2015) found that more sexually active females showed non-significantly more frequent sexual vocalization than less sexually active females. Second, more promiscuous Guinea baboon females showed more frequent sexual vocalization than their less promiscuous counterparts (Maestripieri et al., 2005). The functional significance of more frequent/intense vocalization in humans may lay in paternal investment. When paternity certainty is low, males reduce paternal investment in both humans (Alvergne et al., 2009, 2010; Anderson et al., 2007; Apicella & Marlowe, 2007) as well as in non-human animals (Alonzo & Klug, 2012; García-Navas et al., 2013; Neff, 2003). Sexually less restricted females may use sexual vocalization to increase their sexual attractiveness to their current partner (Younis & Ibrahim, 2015) by means of boosting their partner's self-esteem (Brewer & Hendrie, 2011). Partner's self-esteem could also be manipulated by pretended vocalization (this study). This answers the proximate part, but the ultimate part (why are make egos connected to partner orgasm?) is still unanswered. An alternative explanation could be that the higher sex drive of sexually unrestricted individuals (Ostovich & Sabini, 2004) could be associated with higher sexual arousal which could, in turn, result in more frequent sexual vocalizations. Sociosexuality in this study did not positively correlate, however, with sexual arousal in their last sexual intercourse; thus, this explanation seems unlikely.

Female sexual arousal was higher during the fertile window of their menstrual cycle which corroborates research showing that the fertile phase of menstrual cycle is associated with significantly greater genital arousal (Suschinsky et al., 2014), female attention to sexual stimuli (Laeng & Falkenberg, 2007), and greater overall interest in sex (Gangestad et al., 2010; Shirazi et al., 2019). Furthermore, I found evidence that females produce sexual vocalization more frequently (but no more intensively) than during the non-fertile phase of their menstrual cycle (Hypothesis 8). Higher frequency of sexual vocalization during the fertile phase of menstrual cycle corroborates similar findings in some non-human primates (Aujard et al., 1998; Pfefferle et al., 2008). The null effect of conception risk on the intensity of sexual vocalization agrees with several recent studies, often based on a detailed acoustic analysis of call structure and analyses of female reproductive hormones, showing no evidence for more intense sexual vocalization during the fertile phase in non-human primates (Bernaldo de Quirós et al., 2018; Clay

& Zuberbühler, 2012; Engelhardt et al., 2012; Townsend et al., 2011).

In agreement with the above-mentioned works, our results suggest that human females do not provide precise information about the timing of ovulation. This can be beneficial to the female in terms of increased confidence of paternity of the current sexual partner through acoustic information corroborating female fertility. Such behavior may ultimately stimulate repeated mating and the probability of conception with a target, high-quality male (Maestripieri & Roney, 2004) and/or gaining paternal investment via concealed ovulation (for a discussion see Burley, 1979). Importantly, however, more objective indicators of cycle status and larger sample sizes are required to classify women correctly into a low and high conception phase (Gangestad et al., 2016) before any definite conclusion can be made.

At least 50% of women reported pretending a copulatory orgasm at least once in their lifetime (e.g., Muehlenhard & Shippee, 2010; Wiederman, 1997; Younis & Ibrahim, 2015). It was hypothesized (Hypothesis 9) that pretending orgasm might correlate with pretended vocalization. In line with this hypothesis, females who reported pretending orgasm were more likely to report pretending sexual vocalization. Pretended vocalization may have identical or at least similar reasons as pretended orgasms. It can be used for deception or manipulation of the partner (Brewer et al., 2016), but it can be also used as a mate-retention tactic, particularly when a male partner has extra-pair mating opportunities (Kaighobadi et al., 2012). Strengthening of the partner's ego, which was one of most frequently reported reasons for pretending vocalization, could serve as a mate-retention tactic and/or as strengthening the pair bond tactic (Hamilton & Arrowood, 1978).

In conclusion, human sexual vocalization is a form of female sexual signaling. It is stronger in individuals with a higher willingness to engage in uncommitted sexual relations (internal factor) and when the arousal during sexual intercourse is higher (external factor) and partly dependent on the timing of ovulation. Sexual vocalization seems to be independent from orgasm, but its pretended form is strongly associated with pretended orgasm. This suggests that sexual vocalization can function to both stimulate and manipulate male sexual behavior by females, which can ultimately secure higher paternal investment and increase the confidence of the paternity of current sexual partner. Overall, results were in greater support of the sire choice hypothesis than the strengthened pair bond hypothesis. Further research may benefit from repeated interviewing of spouses in order to obtain more reliable information from both partners during various stages of a female's menstrual cycle.

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Declarations

Conflict of interest The author declares that he has no conflicts of interest with respect to their authorship or the publication of this article.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All study procedures were approved by the Ethics Committee of the Comenius University, prior to data collection.

Informed Consent Informed consent was obtained from all individual participants included in this study.

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