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Menstrual cycle phase alters women's sexual preferences for composers of more complex music

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Over 140 years ago Charles Darwin first argued that birdsong and human music, having no clear survival benefit, were obvious candidates for sexual selection. Whereas the first contention is now universally accepted, his theory that music is a product of sexual selection through mate choice has largely been neglected. Here, I provide the first, to my knowledge, empirical support for the sexual selection hypothesis of music evolution by showing that women have sexual preferences during peak conception times for men that are able to create more complex music. Two-alternative forced-choice experiments revealed that women only preferred composers of more complex music as short-term sexual partners when conception risk was highest. No preferences were displayed when women chose which composer they would prefer as a long-term partner in a committed relationship, and control experiments failed to reveal an effect of conception risk on women's preferences for visual artists. These results suggest that women may acquire genetic benefits for offspring by selecting musicians able to create more complex music as sexual partners, and provide compelling support for Darwin's assertion 'that musical notes and rhythm were first acquired by the male or female progenitors of mankind for the sake of charming the opposite sex'.

1. Introduction

Because music has no clear adaptive value its evolutionary origins remain deeply mysterious [1–4]. One long-standing theory, dating to Darwin, is that the primary biological function of music is sexual courtship, and hence, that music is a product of sexual selection through mate choice [5]. Despite its considerable intuitive appeal, the sexual selection hypothesis of music evolution has received little empirical investigation, and no conclusive evidence has been found to substantiate it. Notwithstanding this, evidence that musical ability may reflect attributes of potential importance in human mate choice contexts is now accruing [6–8]. Furthermore, individuals could indicate their creativity and capacity for learning complex behaviours by producing complex musical sounds [9] and these qualities could be used to discriminate between potential mating partners [10].

Previous work failed to reveal a female bias for more complex music around ovulation [11]; however, because this study did not link compositions differing in complexity with actual composers/performers, it could not rule out the possibility that ancestral women used the ability of men to produce complex music as criteria for mate choice. Indeed, complex sounds are often produced in courtship displays by non-human animals [12], and women appear to prefer creative men as short-term sexual partners during peak fertility [13]. As a result, women may be expected to show heightened sexual preferences during peak conception times for men that are able to create more complex music. If they do, this would provide strong empirical backing for Darwin's original contention that the primary biological function of music is sexual courtship [5].

Here, I investigated whether women's sexual preferences for men able to compose more complex melodies vary with the probability of conception across the menstrual cycle. To this end, I ran two separate two-alternative forced-choice experiments in which women were grouped into high- and low-conception-risk

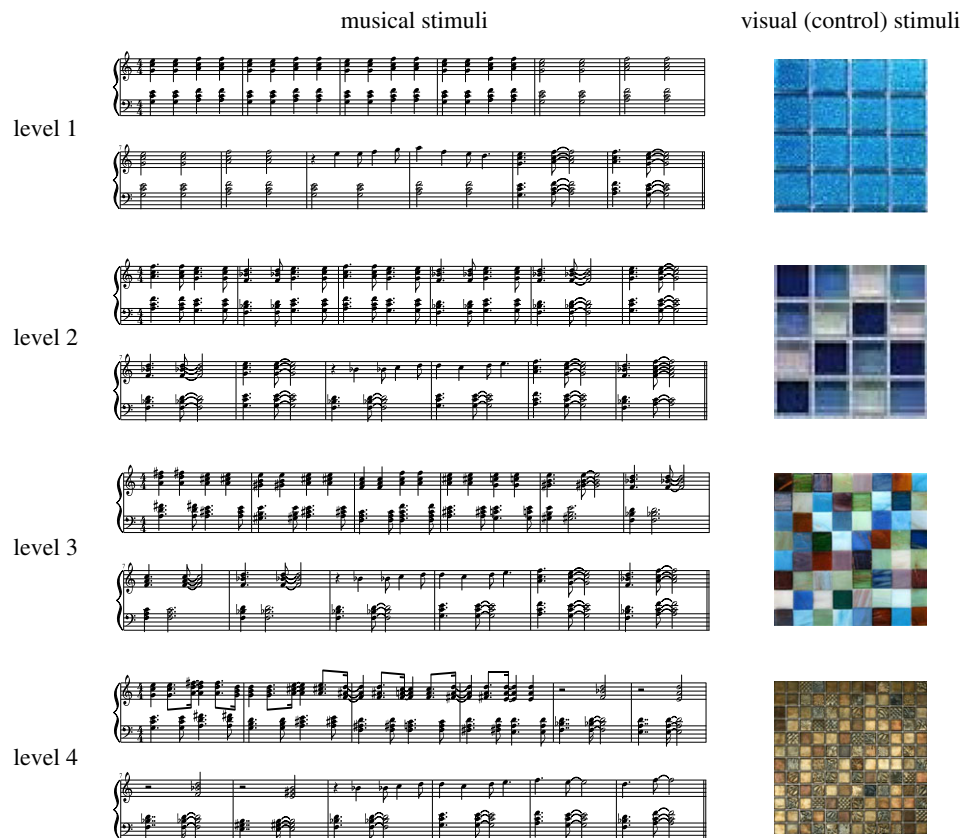


Figure 1. The different levels of stimulus complexity. The musical stimuli on the left were thematically similar piano compositions that were each 12 bars long. Musical complexity was increased through level 1 to 4 by adding syncopation and increasing the number of chords used to create the melodies. The visual (control) stimuli on the right were mosaics representing increasing amounts of visual complexity through level 1 to 4. (Online version in colour.)

groups using reproductive cycle data [14,15] and presented with a stimulus pair consisting of two short melodies each representing one of four different levels of complexity. In the first experiment, women were asked to verify which composition sounded the most complex, in the second experiment, another group of women were asked whether they would prefer the composer of the first or second melody either as a short-term sexual partner or a long-term partner in a committed relationship [13,15]. In addition, to rule out whether any menstrual cycle shift in preferences is owing to a domain general preference for creativity, I also ran a control experiment using visual stimuli representing four different levels of complexity. Of the current theories of music evolution, only the sexual selection hypothesis predicts an effect of reproductive stage on women's preferences (for overviews, see [1,16]). Consequently, if women display preferences for composers of more complex music during the fertile phase of their reproductive cycle that are not observed outside of peak conception times, this would provide strong evidence that sexual selection played a role in the evolution of music.

2. Material and methods

(a) Participants

Women ($n = 1465$) were recruited using the University of Sussex undergraduate subject pool ($n = 261$) and Amazon's Mechanical Turk (MTurk; $n = 1204$). The use of undergraduates and general members of the public provided a diverse sample of women for the study. MTurk workers can browse available tasks and are paid upon successful completion of each task [17]. United States-based MTurk workers with a successful completion rate of 95% or higher

were recruited in order to limit problems understanding English instructions and maximize data quality. Sussex students were awarded course credits, and MTurk workers paid \$1.00 for participating.

(b) Experimental stimuli

(i) Musical stimuli

The musical stimuli were thematically similar piano compositions that were constructed using the grand piano midi instrument in GARAGEBAND (Apple Inc.) and represented four different levels of complexity (figure 1 and the electronic supplementary material, audio files S1–S4.mp3). Complexity differences were achieved by increasing the number of chords used to construct the melodies and introducing syncopation, both of which are known to increase the perceived complexity of music [18,19]: level 1 had two different major chords (C, F) and was played without syncopation (notes produce off the beat); level 2 had three different major chords (C, F, Bb) and the same syncopated pattern in both clefs for the first eight bars; level 3 had six different major chords (C, F, Bb, D, A, E) and syncopation in the bass but not the treble clef for the first eight bars; level 4, the most complex of the set, had seven different major chords (C, F, Bb, D, A, E, G, D9) and different syncopated patterns in each clef. The 12 different stimulus pairings represented all combinations of the four different complexity levels in which melodies differed in complexity (figure 2*a*). The tempo of the melodies was set to 135 beats min^{-1} .

(ii) Visual stimuli for the control experiment

For the control experiment, I used mosaics downloaded from <http://www.wallsandfloors.co.uk/category/mosaic-tiles/>. The mosaics were chosen to represent four different levels of complexity (figure 1). Level 1, the simplest mosaic, had 4×4 rows of light blue coloured squares; level 2 had 4×4 rows of light

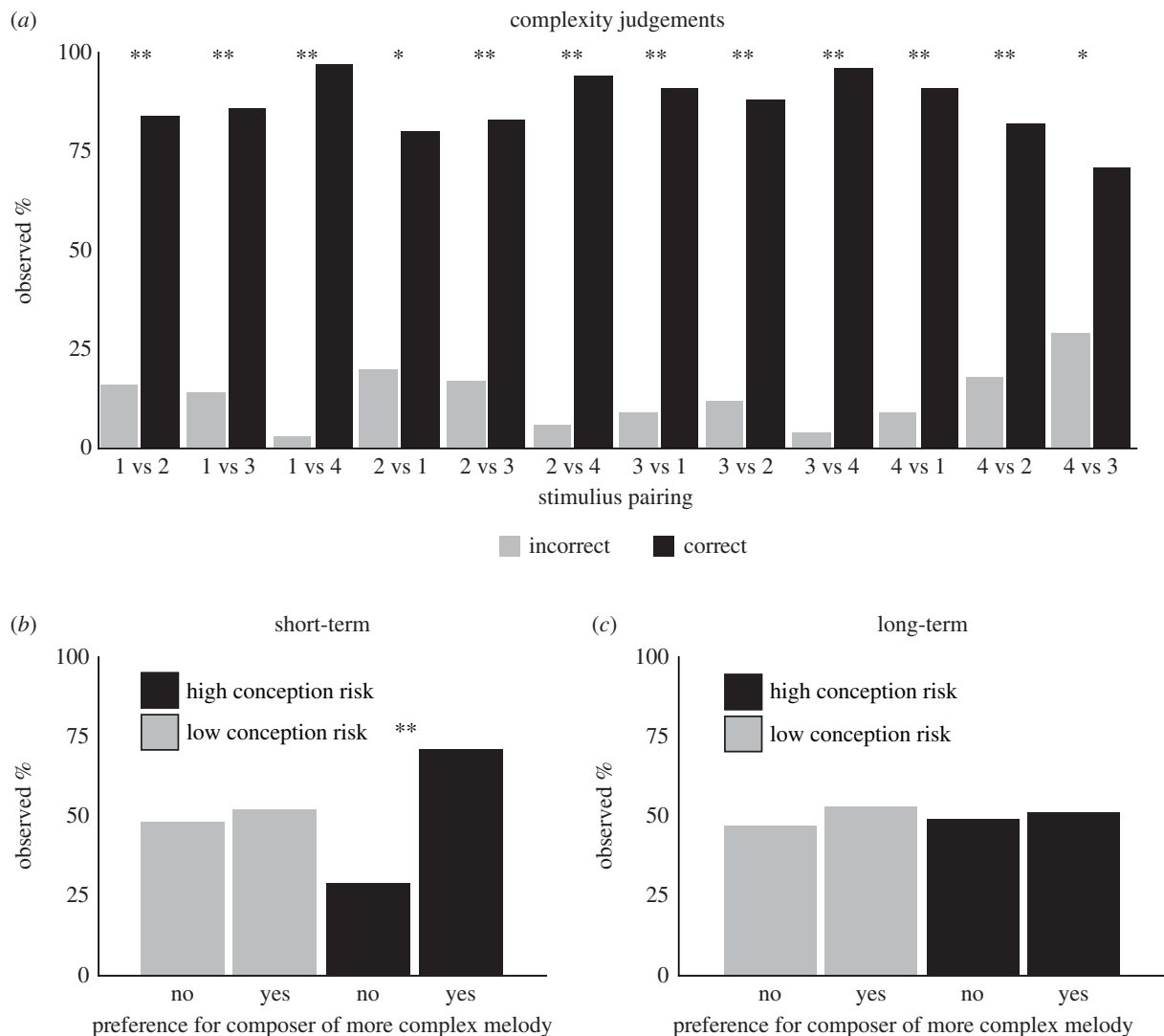


Figure 2. Women's complexity judgements and choice of composer. (a) Complexity judgements for the different stimulus pairs. (b) Short-term sexual preferences for composers of melodies differing in complexity at high- and low-conception-risk phases. (c) Long-term partner preferences at high- and low-conception-risk phases. * $p < 0.05$, ** $p < 0.001$.

blue, dark blue and white coloured squares; level 3 had 8×8 rows of squares in six different colours (red, green, blue, white, brown and pink) that also ranged from light to darker shades; and the most complex mosaic, level 4, had 16×16 rows with squares that ranged from light to dark brown colour and were either without patterning or contained one of six different patterns.

(c) Experimental procedures

(i) Musical complexity experiment

Women that reported regular menstrual cycles and were not currently breast feeding, pregnant or using hormonal contraception (mean age 27.9 years and mean cycle length 28.2 days) were directed to a web-based experiment hosted on www.wix.com (see the electronic supplementary material) where they gave informed consent and provided information about their age, relationship status, years of formal musical training, average menstrual cycle length and date of onset of previous menses. Participants were then presented with a stimulus pair consisting of two (20 s) melodies each representing one of four different levels of complexity (figure 1). The musical stimuli were uploaded to the online experiment as mp3 files, and stimulus pairings were randomly allocated to each participant using the 'Math.random' command in HTML. Subject data and responses were automatically time-stamped and archived using <https://drive.google.com/>.

Two separate experiments were conducted: in the first experiment, women were asked to choose which composition sounded the most complex; in the second experiment, another group of women were asked whether they would prefer the composer of the first or second melody either as a short-term sexual partner or a long-term partner in a committed relationship. We used different subjects for the second experiment to eliminate any potential artefacts that might arise from subjects' notions about relationships between complexity and preference judgements [20]. The paradigm for the preference judgements allows us to determine whether any preferences are based on women's incentives to secure the indirect genetic benefits of 'good genes' for their offspring (heritable genetic quality) or direct benefits such as food and shelter (parental investment ability) (*sensu* [13,15]). Because conception can only occur during the fertile phase of the reproductive cycle, we expect any preferences based on 'good genes' indicators to be revealed at this time [21]. Cyclic shifts in preferences are not predicted for traits valued in long-term mates [21].

(ii) Visual complexity (control) experiment

The visual complexity experiment was designed to reveal whether any menstrual cycle shift in preferences for composers of more complex melodies simply reflects a general attraction towards creative skill. In this experiment, I used exactly the same web-based experimental approach to present women (mean age 25.4 years

and mean cycle length 27.5 days) with visual stimuli called 'mosaics' (figure 1 and the electronic supplementary material). Women that reported regular menstrual cycles, were not colour blind, currently breast feeding, pregnant or using hormonal contraception were either asked to rate the complexity of the mosaics, or choose whether they preferred the artist that created the mosaic on the left or the right of the screen either as a long-term or short-term partner. Participants were required to provide information about their age, relationship status, years of formal artistic training, average menstrual cycle length and date of onset of previous menses.

(d) Conception-risk groups

Following other studies of this type [14,15], women on days 6–14 of their reproductive cycle (corresponding to the late follicular stage) were placed in a 'high-conception-risk' group, and women at all other stages of their cycle were placed in a 'low-conception-risk' group. Women on days 15 and 16 were excluded from the analysis because they cannot be reliably assigned to the late follicular or luteal phases without using hormonal assays. In addition, to avoid any potential effect of menstruation on preference or complexity judgements, women on days 28–5 were also excluded from the analysis [14,15].

Before assigning participants to these groups, menstrual cycle day was normalized to a 28-day cycle using the reported cycle length [11,22]. Cycle day was normalized by taking the average cycle length in days, dividing 28 by the cycle length to create a correction factor and then multiplying each woman's day in the cycle at the time of the experiment by this correction factor. For example, a women with a 28 day average cycle length would have her current cycle day multiplied by $28/28 = 1$ (not corrected), whereas a women with an average cycle length of 40 days would have her current cycle day multiplied by $28/40 = 0.7$ and hence, reduced.

(e) Statistical analysis

Generalized linear models (GLMs) with maximum-likelihood estimation and binomial tests were used to examine variation in complexity judgements and preferences for the different composers/artists. For each GLM, participants' responses were entered as a binary logistic dependant variable, conception risk (high versus low) and subject origin (MTurk or Sussex) as between-subjects factors and subject age and years of formal musical or artistic training as continuous variables. For the analysis of the preference tests, women's current relationship status (single or with a long-term partner) was also entered as a between-subjects factor. Statistical tests were conducted using IBM SPSS statistics v. 20 for Mac OS X, and significance levels were set at 0.05. All the datasets are provided as electronic supplementary material.

3. Results

(a) Musical complexity experiment

During the forced-choice tests, women that were asked to choose which composition sounded the most complex correctly selected the more complex melody 86.4% of the time (binomial test: $n = 265$, $p < 0.001$), confirming that they perceived the more complex melody of the stimulus pair as sounding more complex. In addition, women judged the more complex melody of each stimulus pair as sounding the most complex in all of the stimulus pairings (figure 2a). Conception risk (Wald $\chi^2 = 0.032$, $p = 0.857$), subject origin (Wald $\chi^2 = 1.675$, $p = 0.196$), age (Wald $\chi^2 = 0.399$, $p = 0.528$) and years of formal musical training (Wald $\chi^2 = 0.035$,

$p = 0.851$) did not significantly affect the ability of women to correctly choose the more complex melody.

In the second experiment ($n = 629$), a significant main effect of conception risk was revealed for short-term (Wald $\chi^2 = 12.395$, $p < 0.001$) but not long-term preferences (Wald $\chi^2 = 0.019$, $p = 0.891$). Relationship status, subject origin, age and years of formal musical training did not affect women's short-term (relationship status: Wald $\chi^2 = 2.102$, $p = 0.147$; subject origin: Wald $\chi^2 = 0.059$, $p = 0.808$; age: Wald $\chi^2 = 0.017$, $p = 0.897$; years of formal musical training: Wald $\chi^2 = 0.168$, $p = 0.682$) or long-term preferences (relationship status: Wald $\chi^2 = 0.010$, $p = 0.919$; subject origin: Wald $\chi^2 = 3.568$, $p = 0.059$; age: Wald $\chi^2 = 0.616$, $p = 0.433$; years of formal musical training: Wald $\chi^2 = 0.000$, $p = 0.994$). Thus, women's choice of composer was consistent across the different subject groups and not significantly affected by their relationship status, age or years of formal musical training. Binomial tests confirmed that women preferred composers of the more complex melody as short-term sexual partners in the high-conception-risk phase of their menstrual cycle ($n = 148$, $p < 0.001$) but not in the low-conception-risk phase ($n = 192$, $p = 0.516$) (figure 2b). By contrast, no preferences were observed when women were asked to choose composers as long-term partners (high-conception-risk phase: $n = 136$, $p = 0.797$; low-conception-risk phase: $n = 153$, $p = 0.628$) (figure 2c).

(b) Visual complexity control experiment

Women correctly selected the more complex mosaic 95.4% of the time (binomial test: $n = 108$, $p < 0.001$) and judged the more complex mosaic of each stimulus pair as looking the most complex in all stimulus pairings (all $p < 0.05$). Complexity judgements were not affected by conception risk (Wald $\chi^2 = 0.001$, $p = 0.970$), subject origin (Wald $\chi^2 = 0.628$, $p = 0.428$), age (Wald $\chi^2 = 1.317$, $p = 0.251$) and years of formal artistic training (Wald $\chi^2 = 0.397$, $p = 0.529$). In the preference tests ($n = 463$), conception risk, relationship status, subject origin, age and years of formal artistic training did not affect women's short-term preferences (conception risk: Wald $\chi^2 = 2.108$, $p = 0.147$; relationship status: Wald $\chi^2 = 3.305$, $p = 0.069$; subject origin: Wald $\chi^2 = 0.158$, $p = 0.691$; age: Wald $\chi^2 = 0.683$, $p = 0.408$; years of formal musical training: Wald $\chi^2 = 0.034$, $p = 0.855$) or long-term preferences (conception risk: Wald $\chi^2 = 0.174$, $p = 0.677$; relationship status: Wald $\chi^2 = 0.613$, $p = 0.434$; subject origin: Wald $\chi^2 = 0.000$, $p = 0.999$; age: Wald $\chi^2 = 1.745$, $p = 0.187$; years of formal musical training: Wald $\chi^2 = 0.049$, $p = 0.825$).

4. Discussion

These results show that women have sexual preferences for composers of more complex music during peak conception times, but not outside this time. By contrast, a menstrual cycle shift in preferences was not seen when women were asked to choose which composer they would prefer as a long-term partner, or during the control experiments using visual stimuli varying in complexity. Hence, the cycle shift in women's sexual preferences for different composers does not appear to reflect a general attraction towards creative skill. During the fertile phase of the menstrual cycle, women are particularly attracted to indicators of genetic quality in potential sexual partners [13–15,22–24]. This is because heritable

genetic benefits (i.e. 'good genes') can only be obtained for offspring if conception follows copulation [21,22]. By contrast, cyclic shifts in preferences are not predicted for traits valued in long-term mates [21]. Consequently, the findings of this study indicate that women may acquire genetic benefits for offspring by selecting musicians able to create more complex music as sexual partners.

Complex sounds are often produced in courtship displays by non-human animals that signal the callers' intrinsic quality to mates [12]. In addition, because increased musical aptitude indicates higher general intelligence [6,7] and may reflect a greater ability to acquire language [25], the ability to create complex music might be indicative of advanced cognitive abilities. Selection could therefore have favoured men who produced more complex musical displays and women that chose these individuals as mating partners. Because women did not prefer composers of more complex music as long-term partners, however, it appears that the ability to produce complex musical sounds does not reflect skills valued in long-term mates (i.e. increased ability to acquire material benefits such as food and shelter).

Current theories of music evolution contend that music is either a non-adaptive by-product of speech or the auditory system in general [26], or that it serves biological functions in the contexts of courtship [5,9], social group cohesion [27] and mother–infant song [28]. While the results of this study do not demonstrate that sexual courtship was the primary function driving the evolution of human music, they do support the contention that women use (or ancestrally used) the ability of male composers to create complex music as criteria for mate choice. Consequently, increased musical complexity may have evolved, at least in part, through female choice for short-term sexual partners. Indeed, computer simulations of music evolution confirm that sexual selection will favour ever more complex acoustic sequences [29], and the propensity of men to produce music, even in cultures where women are freely allowed to do so, is also consistent with the hypothesis that music has a biological role in sexual courtship [9].

Nevertheless, it must be noted that sex differences in musical ability do not appear to exist [9] and music is also clearly important in non-sexual contexts [1]. Future work, therefore, should attempt to disentangle the various selective forces driving music evolution, perhaps by establishing an adaptive role for music in the development of infant cognitive abilities and/or for signalling social group cohesion.

I suggest that music may have manifested itself in courtship contexts by allowing both men and women to display specific adaptive qualities. For instance, the ability to play an instrument could reflect excellent physical coordination and learning capacity. Men and women may also have sung to each other to show how they can improvise novel melodies, and perhaps display their creativity and ability to innovate. Accordingly, future work should investigate whether men also prefer women able to produce more complex music as sexual partners, as well as determining whether men and women base sexual preferences on the ability to produce complex vocal sounds during singing performances. If they do, this would provide further evidence that sexual selection played a role in the evolution of music. Although the origins of music are much debated [1–4], we still understand very little about how this universal aspect of human culture evolved. The findings of this study confirm that a possible ancestral role for music may in some cases have been to attract sexual partners, and constitute the first empirical support for Darwin's [5] original contention that music evolved via sexual selection.

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