

On the propagation of musicality: Taking cues from sexual selection

by

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Abstract

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There is a shortage of empirical literature on the evolutionary functions of music. An overview of the evolutionary theories of music indicates that direct natural, indirect natural, and by-product explanations for the propagation of musicality are unlikely. Research demonstrates that music ability fulfills many of the criteria for a sexually selected adaptation suggesting that contemporary entailments of music may be sexually selected for. However, there has been no empirical investigation of the sexual selection theory of music. This study aimed to: (1) investigate if music is sexually selected for; (2) examine the influence of variables known to affect mating on musical production; and (3) investigate the underlying cognitive constructs of musical production. Using a sample of 92 undergraduate students, aged 18 to 30, several planned tasks examined the effects of sexual and romantic arousal on the production, aptitude, and subjective rating of music. Using a between subjects design, participants read a neutral, short-term mating, or long-term mating vignette before completing tasks assessing musical aptitude, intelligence, divergent thinking, and executive functions. Results indicated that being primed for long term mating increased displays of musicality in both sexes, *but* when participants were primed to think about short-term mating, only male participants showed increased ratings for musical production. These findings align with the view that displays of music in both

sexes may be associated with sexual selection, qualified by amount of parental investment. Results also revealed that musical production was not affected by variables known to affect mating such as mood, ovulation status, current mating situation, caffeine intake, or sex of the raters but musical production was affected by current mating situation and sex of the rater. Possible explanations for these findings are discussed. Finally, results revealed no meaningful association between mental flexibility (as measured on tasks of divergent thinking, executive functioning, and IQ) and musical production suggesting that musical production may not be showcasing a fitness for the 'g' factor. Taken together these results provide empirical support for Miller's hypothesis that music is, or has recently been a sexually selected adaptation.

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Introduction

The origins of music have been studied since Darwin first proposed that music had its roots in language and emotion and is sexually selected for (Darwin, 1871). Great strides were made in the Berlin school of comparative musicology in the first half of the 20th century. At the Berlin school, musical constructs (scales, intervals, and rhythmic organization) from all over the world were recorded and considered under the intellectual scope of music, anthropology, and psychology. Unfortunately interest fell out of fashion in the early 1940s as behaviorism took a stronger hold of psychology.

Recently, there has been a resurgence of interest in the origins and functions of music (Miller, 2001; Peretz, 2001; Zatorre, Evans & Meyer, 1992). For example, Wallin (1991) introduced the field of biomusicology, which focuses on the intersection between evolutionary musicology, neuromusicology, and comparative musicology and offers new perspectives on the origins and functions of music. Biomusicology enables researchers to answer questions related to the origins of music by combining information from the fields of anthropology, neuropsychology, and creativity using an evolutionary perspective. When trying to understand the behavior that gave rise to Beethoven's fifth symphony, for example, biomusicologists first identify similar behavior in other species (e.g., bird songs) and then speculate about the selection pressures that might have transformed simple sound mimicking into the complex behavior of synthesizing and creating novel combinations of sound. Neuromusicologists investigate what neural regions are used for listening, creating, and playing music by identifying patterns of significant brain activation as people perform musical tasks in a magnetic resonance imaging (MRI) scanner, by

understanding musical deficits caused by damage to specific brain regions, and by exploring the density of neurons postmortem. Ideally, once a theory is shaped, empirical investigation using various methodological approaches can ensue. This Introduction will summarize current theories on the evolution of music and outline possible neurological and neuropsychological abilities that enabled the emergence of music.

Theories on the evolution of cognitive modernity and its relation to aesthetic modernity

Evidence for the first musical instruments, bone flutes found in Geissenklosterle, Germany, date back to the time period of roughly 36,000 years ago (Lau, Blackwell, Schwarcz, Turk & Blickstein, 1997; Morley, 2006). The number of human instruments has increased exponentially since then. The archeological record dating back 36,000 years ago, however, does not show evidence of an increase in brain size at this time. While human brain size remained relatively stable, what emerged was evidence for advanced thought and corresponding behaviors including many that fall within the domain of artistry (e.g., decorating pottery and carving bones into musical instruments).

These observations raise a couple questions. First, what physiological and/or cognitive augmentations underlie the emergence of music? Second, what advantages did such cognitive changes, such as music afford? To begin we will consider theories exploring the cognitive augmentations of human evolution.

Coolidge and Wynn's central executor

Coolidge and Wynn (2005) explain the sudden surge advancement of thought

36,000 years ago as a product of the evolution of executive functions. Executive functions are a group of brain processes that enable such higher order abilities as planning, cognitive flexibility, initiation of actions, and the overriding of automatic responses (Lezak, 1995). Coolidge and Wynn conceptualize executive functioning as encapsulating working memory and even state that working memory could be re-termed “working attention” (Coolidge & Wynn, 2005, p.7). According to these researchers, humans had certain abilities essential for executive functioning at earlier times in prehistory-- such as a capacity to hold digits in mind (working memory), play recent auditory information back in their minds (phonological loop), or move objects around in the mind (visio-spatial sketchpad).

Each of these executive function components has identified neural correlates. For example, the dorsolateral prefrontal cortex has been shown to be associated with problem solving, decision making, verbal fluency, and some operations of working memory. The orbitofrontal area is coupled with the limbic system and linked with regulating emotions and social behavior. The prefrontal cortex has diverse connections with regions of the parietal lobes, temporal lobes, basal ganglia, cerebellum, and brainstem. The prefrontal cortex is understood to coordinate processing (Joseph, 2000).

Coolidge and Wynn argue that the presence of a central executor integrating the dorsolateral frontal lobe, orbitofrontal area, and anterior cingulate gyrus is responsible for executive function and marks the onset of modern behavior. They are careful to point out that all three parts would need to be sufficiently evolved for the combination to be as fruitful as the archeological record indicates. They offer the possibility of two types of genetic mutations (described below) that may have allowed for this integration of

substantially advanced components, and made it possible for early humans to make decisions about information held in their phonological stores and visuospatial sketchpads. Archeological evidence supports this claim. Although there was no overall brain increase with the emergence of behaviorally modern humans 30,000 years ago, enlargements did occur in the prefrontal and orbitofrontal regions (Deacon, 1997).

Coolidge and Wynn contend that the emergence of behavioral modernity could have occurred through *domain-specific* or *domain-general* mutations. A domain-specific mutation would have affected the processing capacity of the phonological loop, increasing the amount of information that could go into long-term storage and be consciously manipulated. Their other hypothesis is that a mutation caused an increase in executive functions, which increases the ability to sustain attention and manipulate information from multiple domains (Coolidge & Wynn, 2005). In either case, the coordinated and combined efforts of these substantially evolved capacities marked the onset of cognitive modernity.

Deacon's emergent complex system

Deacon calls cognitive modernity an “emergent complex system effect” (Deacon, 2006, p. 29), meaning that modern cognitive abilities developed from the interplay between many augmentations to subservient neural systems. Deacon argued that “something more” arises out of human cognitive systems. Although many of the systems subservient to cognition can be identified inside the brain, the “something more” that emerges out of the interplay between these systems is uniquely human and unidentifiable.

Deacon believes that aesthetics are also a product of this emergent complex system

effect. Specifically, he asserts that humans have the *special* ability of exploring symbol-symbol association, such that they can compare hundreds of associations between concepts and emotions. The ability allows for generative combinations more complicated and intricate than combinations made by other species. Novel combinations contain the referent symbol or emotion but embody “something more” that is uniquely human. For example emotion vigilance is a combination of interest and anticipation, but it embodies something more than the sum of its parts. Music, art, and poetry emerged out of symbol-symbol comparisons of concepts and emotions as vehicles to communicate (or experience) something novel. In Deacon’s view, symbol-symbol comparisons increased survival rates in early humans by allowing them to practice outcomes mentally without consequence. Just as cubs play to practice the skills needed to hunt, humans need to practice skills needed to think. Early humans’ urge to master thinking “shifted selection on human cognitive capacity to this emergent synergistic composite function” (Deacon, 2006, p. 33).

Feist’s cognitive capacities

Feist (2004, 2007) would agree that emergent synergistic functions are the basis of modern cognitive abilities, but refers to them broadly as creativity. According to Feist, before the first brain enhancement, early humans were pre-representational, reacting to each moment via a series of reflexes. Premodern humans lacked the ability to think about that which was not providing immediate sensory stimulation. After the first enlargement, Feist categorizes humans as having representational minds, the ability to hold something in mind beyond immediate sensory-perceptual experiences. Thus, these pre-humans (*Homo ergasters*) could probably remember where a good food stash was located, though they

were incapable of thinking about what they might eat in the food stash. Feist (2004) also argued that approximately 60,000 to 30,000 years ago, behaviorally modern humans began to exhibit metacognition, or the ability to think about thinking. These behaviorally modern humans not only knew where a food stash was located, but they could contemplate reasons why another hiding place might be better. They also could consider whether they wanted to eat the tomato with the wheat grass or save it for tomorrow.

Evolutionary functions of music and aesthetics

Efforts to understand the sudden explosion in the archeological record 36,000 years ago and the first evidence of aesthetics converge on the idea that the minds of early humans developed a greater ability to manipulate thought. The exact sequence of events that led to the first human having modern cognition, will probably remain unknown. Understanding theories of the emergence of modern thought can help shape evolutionary theories on the propagation of cognition and aesthetics. For example Feist (2007) credits the emergence of modern thought and creativity to the capacity for metacognition, but states that over the next millennium “different forms of selection have shaped different forms of creativity” (p. 17), such that technical or applied creative behavior were naturally selected for whereas art and music were sexually selected for. Deacon (2006) also credits metacognition with the emergence of aesthetics and music, the advantages of which are more elusive.

Evolutionary theory distinguishes between direct natural selection, indirect natural selection, sexual selection, and by-products as possible mechanisms that promote change within a species (De Pandafieu, 2007). Change is produced within an organism through

mutation and/or recombination of genes. If these changes are advantageous to the organism, then they will be selected for. Traits that directly or indirectly increase survival (e.g., great speed in cheetahs) are passed along to the next generation through natural selection. Sexually selected traits (e.g., such as collecting blue objects by male bower birds to build a “pretty” nest for mates) have been passed down through the generations because they increase the chance of mating, and not survival directly. According to Darwin (1871) all traits and behaviors have a genetic basis and are subject to selection pressures. Based on this assertion, researchers have begun to expand their understanding of uniquely human traits like art and music by identifying possible advantages that music and art may have provided and subsequently been selected for (Miller, 2000b; Dutton, 2009). Dissanayake (2007) provides an overview of the possible advantage of aesthetics (including music), delineating four possibilities; (1) direct natural selection, (2) indirect natural selection, (3) sexual selection, or (4) by-product.

(1) Direct natural benefits

First, aesthetics could have *direct natural* benefits that would increase the chance of survival by affecting a survival trait. Some believe that aesthetics enable deeper exploration of the environment allowing for a more complete knowledge of it (Zeki, 2002). Zeki takes a reductionist view on the human response to art stating that “we can trace the origins of [an artists’] art to fundamental characteristics of the brain, namely its capacity to form concepts” (Zeki, 2002, pg. 1). He believes that artists create pieces that they intuitively know affect foundational aspects of the visual or auditory system, thereby increasing exploration and knowledge of that particular foundational aspect. For example

Wagner's Tristan Chord, an unresolved dissonant chord, which at the time of its introduction was completely novel, is thought by Zeki to be irresolvable or resolvable in many ways for the brain. That is to say the ambiguity of the Tristan Chord allows the listener to come up with many possible resolutions, increasing knowledge of the chord and consequently the amount of activation in the brain, a rewarding experience (for a discussion of brain activation and rewarding experience see Mardindale, 2007). Although it is easy to understand how forming concepts is advantageous to human beings, the specifics of forming concepts about chords, or abstract art, are more illusive. Music and art may provide a mechanism for practicing abstract thinking but practice is better understood as an *indirect natural benefit* than a *direct natural benefit* (see below). Evidence that many possible resolutions or concepts for chord resolution are as advantageous as numerous hunting strategies has yet to be demonstrated. Therefore, like the Tristan Chord, this issue remains unresolved.

(2) Indirect natural benefits

Second, aesthetics may have *indirect natural* benefits. An indirect natural benefit increases the chance of survival by affecting correlated traits that would not enhance the chances of survival directly. Here we will discuss four proposed indirect natural benefits of music: practice, parent-child bonding, group cohesion, and protolanguage.

Practice. Aesthetics and music may have allowed for risk-free practice through imagination, concept expansion, drawing, or singing. For example, having an imagination may enable individuals to practice real or novel scenarios in their mind, better preparing them for real life situations. Consider the situation of a lion attack. Early humans who had

previously considered this situation may have responded more quickly giving them an indirect survival advantage. That said, direct benefits such as strong, fast legs would probably prove more useful. It has also been proposed that music may enhance cooperation such as signing to increase productivity. Additionally most of the theories considering indirect fitness focus on fitness as it pertains to groups, but the selection process acts solely on an individual level.

Parent child bonds. Increased infant survival facilitated by stronger parent child bonds through singing is characterized as an indirect benefit of music (Dissanayake, 2000). Dissanayake and others (Fitch, 2006; Mithen, 2005) state that music may enable the modulation of emotional arousal thereby promoting infant survival an/or development. Although we cannot travel back in time and observe if music provided the indirect benefit of infant survival, we can look at the current population for evidence that music is used in parent-infant bonds, that it can modulate arousal and that it is ubiquitous. Evidence of this type would provide support, but never indisputable evidence that contemporary entailments of music may be indirectly selected for.

Let's turn to the evidence: the use of soothing, melodic speech and songs from mother to child can be found in every culture around the world, indicating a common evolutionary origin. Songs directed at infants across the globe tend to be sung at a higher pitch and in a more repetitive style than other singing by mothers (Bergeson & Trehub, 1999). Infants direct attention more quickly and for longer periods of time when the mother is singing an infant-directed song (Trehub & Hannon, 2006). Infant-directed songs draw attention to important stimuli, ease infants when they are upset, induce sleep, and precipitate changes

in saliva cortisol levels (Trehub & Hannon, 2006). Therefore many assert that the function of this type of song is to mediate arousal of infants (Bergeson & Trehub, 1999; Halpern, 1989; Masataka, 1999; Nakata & Trehub, 2006; Trainor, 1996; Trainor & Zacharias, 1998; Trehub & Nakata, 2000).

Research indicates that infants' attention to music is predisposed (Trehub & Hannon, 2006). "All of us are born with the capacity to apprehend emotion and meaning in music, regardless of whether we understand music theory or read musical notation" (Tramo, 2001, p.54). A common experiment used to investigate the effects of music on attention uses a puppet show and a laterally placed speaker. The speaker plays music in a repetitive manner and makes slight changes to the pitch, tone, timbre, or rhythm. When the infant looks at the speaker immediately after such a change is made, this gaze is recorded as a "different" response; if the child does not look at the speaker after such a change is made, a "same" response is recorded. Investigations like these have demonstrated that infants (birth to 11 months) respond to changes in pitch, timbre, tone, and rhythm as well or better than adults (Trehub & Hannon). What this indicates is a predisposition to attend to music.

Research also indicates that arousal is affected by music. One of the ways that the brain modulates arousal is through brainstem reflexes. The perceptual system is consistently scanning the world for changes. When change occurs within the auditory environment, the auditory system activates the reticular formation of the brainstem, which passes information along to the cerebral cortex via the intralaminar nuclei of the thalamus (Joseph, 2000). The reticular formation is partly responsible for the control of attention, emotional arousal, heart rate, breathing, and movement, as well as other processes. This

system is activated through neurotransmitters such as norepinephrine and serotonin and is a fast-acting system (Joseph, 2000). Brainstem reflexes do not require cognitive appraisal but can be activated by the amygdala, hypothalamus, and orbitofrontal cortex. Juslin and Vastifjall (2008) stated that: "Brainstem reflexes can explain the stimulating and relaxing effects of music" (p.564). Effects of this system can be seen both prenatally and in newborns. Fetus heart rates and movement frequencies have been shown to increase as a result of loud music, while movement and heart rate decreased when the mother listened to soft music (Lecanuet, 1996). Furthermore, babies in utero showed a marked increase in heart rate when the mother listened to 15 seconds of a Bach's Organ Prelude (Woodward, 1992).

The above research demonstrates that human babies are attentive to and affected by music from a very young age. The modulation of infant arousal might have provided an *indirect* survival advantage over non-musically responsive infants following the second increase in head size 600,000 to 150,000 years ago. Restrictions on the size of the birth canal resulted in infants being born sooner along the developmental spectrum increasing the vulnerability of newborns (Trevathan, 1987). The human brain is only 25% developed at birth, while close relatives to humans such as chimps and monkeys are born with brains much further along the developmental spectrum (i.e., 40% and 65% developed, respectively) (Trevathan, 1987). Modulation of emotional arousal through music may have increased the probability of infant survival by keeping children quiet in the face of predators. However if music's evolutionary advantage is to modulate emotion to promote *infant* survival, why do thousands of adults gather daily to hear music performances? In

other words, if evolution is selecting for traits that modulate infant emotion why not directly select for calmer babies, instead of indirectly selecting for a costly and complicated system like music? Emotive and attention regulation provide evidence for possible origins of music, but fail to account for contemporary entailments.

Group Cohesion. Another theory on the benefits of music suggests that music facilitates group cohesion, increasing the fitness of the group. For example, music may foster cohesiveness or coordinate large group action. The rhythm of music permits humans to predict when the next beat will fall, and these time signatures can organize activities of several individuals into coordinated movements and behaviors (Merker, 2000). As an example, consider railroad workers. Hammering in the rails on a railroad is a difficult task; rails are stubborn and they do not like to stay in place. Furthermore, the mauls, or long pegs used to attach the rail to the ground, must be hit precisely squarely to prevent the heads from popping off. Rail workers know this and have perfected their windmill hammer swings, but reverberations still cause problems. The common solution is to sing. In this manner, the group alternates swings on the up or down beat of a song to reduce the reverberations and keep the mauls steady, thereby enhancing productivity.

Group cohesion is not limited to material output; coordination of the group might also indicate fitness. Examples of this type of coordinated behavior exist in the animal kingdom. For example, male fireflies flicker in synchrony (Buck, 1988) and chorusing frogs demonstrate coordinated calling (Wells, 1977). In both cases, the objective of the synchrony is to attract mates: the louder or brighter the group of males, the more likely they are to attract mates. Merker (2000) applied this concept to human mating and

benefits of music. In his theory, choral songs are used by groups of males to lure traveling females. His theory is based on the unusual trait of female exogamy observed in chimpanzees (our closest living relative among the apes). Female chimps and presumably female hominids migrate away from their families to live and rear children in a different group. According to Merker, groups of male hominids would call in unison about the location of a fruit tree. This served as an honest signal to the migrating females about the male group's resources and cooperative status. Over time, this choral song evolved into a way to attract females and facilitate copulation. Evolution is conducted at the level of the individual not the group, posing a problem for this theory. Group synchrony is used to attract females, but choruses quickly turn to male rivalry once the females have gathered. Additionally, although females may have migrated away from their families in search of mates in prehistoric times, this behavior is rare in post history.

Language. Music and language share many similarities; they both use auditory and vocal apparatus, they can both take a written format, and they both rely upon the integrity of a number of similar brain areas (Wallin, Merker & Brown, 2000). Music may be an indirect benefit because it is correlated with language. Whether music and language are different aspects of the same thing (i.e. communication) and have similar origins, or if they are separate abilities with different origins, is still being debated.

Steven Brown (2000) outlined five possible models accounting for the evolution of music and language. The first model states that language and music evolved independently and have no shared ancestral features. The second model contends that music and language could have developed from an interaction between aspects of music and language.

The third model contends that music and language both developed from language. The literature does not offer strong support for the first three theories. The fourth model states that both resulted from ancestral features of music alone. Support for the fourth model comes from Darwin (1871) who identified music as a precursor to language, believing that music was the more primitive form of communication and that language evolved out of music as a separate system. The fifth model contends that music and language arose from a common ancestral system of communication. Brown introduced this ancestral system as “musilanguage,” where information was conveyed by pitch rather than morphemes. Mithen expanded Brown’s theory, renaming it the “hmmmm communication system” and adding that it was manipulative, multimodal, musical, and mimetic (Mithen, 2005). As evidence for the hypothesis that music and language evolved from a common ancestral system, Brown cites examples of pitch communication in the animal world (from dolphins, monkeys, and song birds) that conveys information using pitch and rhythm as well as the fact that half of our current 5,000 languages are tonal and make use of pitch.

While the theories outlined above remain under consideration, information about the evolutionary trajectories of music and language can also be gained by examining the anatomy of modern day human brains. Abnormalities in either the language or music system (or the corresponding brain regions) can inform how interactive they are. Additionally, functional and structural neuroimaging studies can reveal areas of activation for both systems helping to disambiguate what brain regions are utilized for language, music, or both.

Research on abnormal brains has suggested that music and language are independent

functions representing disparate systems (Godefroy et al., 1995; Peretz, 1996). Many cases have been documented where aspects of musical ability (but not speech) were affected by accidental focal damage or developmental trauma. For example, accidental damage to the superior temporal cortex in an adult brain can cause an inability to recognize and memorize music (Peretz, 1996; Peretz, Kolinsky, Tramo, & Labrecque, 1994). This damage can leave intact other auditory abilities such as spoken language and sound recognition in the environment, implicating processing areas essential to music only. The opposite pattern has also been found where speech is affected but musical ability remains intact. A case study of a man who suffered from bilateral hemorrhages compromising the external capsule and extending to both temporal isthmi revealed transient deafness for environmental and verbal sounds (Godefroy et al., 1995). Neurodegeneration in Alzheimer's disease patients also demonstrates a disconnect between music and language; many patients lose the ability to speak but maintain the ability to sing and recognize or remember songs (Gagnon, Peretz & Futop, 2009).

A second avenue demonstrating the relationship between music and language comes from amusics and individuals with autism. "D.L.," a famous patient of the neurologist Dr. Oliver Sacks, was diagnosed as amusic at age 70 (Sacks, 2008). She likened music to dropping kitchen pans on the floor, but had normal prosody and language abilities. "Professor B.," a gifted musician who after suffering a stroke could no longer identify the song "Happy Birthday," nonetheless retained the ability to produce and understand language (Sacks, 2008). These specific abnormalities provide evidence for a disconnect between music and language as do more global disorders like autism. Autism is a

neurological disorder characterized by impaired social interaction and communication, and by restricted and repetitive behavior. Yet, many autistic individuals demonstrate greater than average musical abilities (Heaton, Hermelin, & Pring, 1998). Neurological investigations into music and language paint a more complicated picture.

Neuroimaging research has demonstrated that music and language have extensive overlap, particularly in their neurological underpinnings (Falk, 2000). Broca's and Wernicke's areas are known to be associated with the production and comprehension of language, respectively. Broca's area, located in the left frontal lobe around the opercular and triangular sections of the inferior frontal gyrus, and represented in Brodmann's cytoarchitectonic map as areas 44 and 45, has historically been considered exclusively a language area. Sergent (1992) found that Brodmann's Area 44 was activated during sight-reading of music. The neocerebellum also demonstrates overlap between the two systems; it is activated when people are engaged in thoughtful speech *and* when individuals listen to music (Khorram-Sefat, Dierks, Herminghaus & Hacker, 1997).

Some behavioral and neuroimaging studies investigating the location of music and language centers have found that music and language are lateralized in the brain (Auzou et al., 1995; Mazoyer et al., 1993; Mazziotta, Phelps, Cerson, & Kuhl, 1982; Paquette, Bourasse & Peretz, 1996; Petersen, Fox, Posner, Mintun, & Raichle, 1988; Zatorre, Evans & Meyer, 1992), while others show that music and language have extensive overlap and share neural circuitry (Brown, 2000; Jeffries, Fritz & Braun, 2003; Khorram-Sefat, Dierks, Herminghaus & Hacker, 1997; Patel, 2003; Sergent, 1992; Perry et al., 1999; Riecker, Ackermann, Wildgruber, Dogil, & Grodd, 2000). Tervaniemi et al. (2000) conducted a positron emission

tomography (PET) study experimentally manipulating participants' attention by engaging them in a visual word classification task while listening to frequent and infrequent phonetic and musical sounds. They found that listening to phonetic sounds was associated with left hemisphere activation while listening to musical sounds was associated with right hemisphere activation. Therefore, some support has been found for lateralization when generating musical or linguistic phrases and when submissively listening to musical and linguistic phrases. On the other hand a PET study looking at novel melodic and linguistic responses to melodic or linguistic phrases found extensive overlap between the two tasks (Brown, 2006). In an attempt to coalesce these disparate findings, Brown (2000; Brown, Martinez & Parsons, 2006) proposed a model explaining the connections between music, language, and areas of activation. In this view, music and language share resources for audition and vocalization but when generating musical or linguistic phrases, activation resides in separate lateralized parts of the brain.

In the human brain, language and music seem to be part of the same neural networks at some levels of processing and part of separate systems at other levels of processing. Considering the above evidence, the idea of an ancestral communication system, or musilanguage as presented by Brown (2000), seems to work well. In this model, areas of shared activation for music and language are used for basic processing indicating that they are phylogenetically very old. Conversely, areas that are lateralized seem to be involved in analysis (listening tasks) or creation of music and language.

Although musilanguage is a viable explanation for how music may have developed, a rationale for *why* music was selected for is not articulated. It might be inferred that music

and language were naturally selected for because of their communicative abilities. The great expenditure of selecting for two highly sophisticated systems for communication, however, seems unlikely, especially given that language has been the predominant system of communication for all of recorded history. It is more likely that music and language share a common ancestor and that language was naturally selected for its communicative ability while music was sexually selected for.

Although musical ability and musical creativity in early humans likely emerged out of some or many of the emotional, attentional, communicative, and social roots of music, none of these origins provides a reasonable survival advantage on its own. Like the evolution of cognition, it is likely that musical ability and musical creativity are the products of combined origins that were sexually selected for.

(3) Aesthetics may provide no evolutionary benefit

Third, aesthetics may provide no benefit; they may be a by-product of the selection process (Gould & Lewontin, 1979; Pinker, 1997; Vitouch, 2006). Pinker (1997) argues that musical ability is a spandrel, that is, a mixture of ancient evolutionarily useful capabilities that serve no immediate purpose other than mental entertainment. He believes that only a select, privileged, and highly trained segment of society makes music. Pinker's (1997) famous analogy that "music is auditory cheesecake, an exquisite confection crafted to tickle the sensitive spots of at least six of our mental abilities" (p. 45) has spawned fierce debate. Critics of Pinker's view (Dutton, 2009; Miller, 2000a, 2001; Peretz, 2001; Zatorre, Evans & Meyer, 1992) contend that musicality meets the criteria of an adaptation.

Miller (2000a) and Dutton (2009) warn that Pinker's theory misinterprets the purpose of evolutionary perspectives. Dutton contends that identifying music as "cheesecake for the mind" has two major flaws. First, evolutionary psychology is interested in *why* humans love cheesecake; the combinations of fats and sugars represent cravings that were essential for balanced nutrition in the Paleocene era. Second, Dutton (2009) contends that music and aesthetics are "intrinsic elements of the body's physiological system and not by-products of adaptation like spandrels or epiphenomena" (p. 97). Here he draws an analogy to a combustion engine, whose major purpose is torque. Heat is another result of combustion engines, a pure by-product. We do not care if the heat is there or not-- just as long as the engine runs; because of this heat, however, a cooling system is required, and this cooling system, which is essential to a working engine, is an adaptation. In Dutton's view, Pinker confuses by-product and adaptation. Miller agrees that Pinker failed to assess the evolutionary possibilities adequately, scolding that he completely ignored the *other* selection pressure: sexual selection.

(4) Benefits of Sexual Selection

Fourth and finally, aesthetics and music may be adaptive because they increase an individual's reproductive success through *sexual selection* (Dutton, 2009; Falk, 2000; Levitin et al., 2003; Miller, 2000a). Thus, aesthetics may contribute to mating opportunities by aiding in mate choice or by evolving as an honest signal of commitment or fitness. Darwin (1871), the first to propose that music is the product of sexual selection, believed that human music was used in courtship because it was an honest and costly indicator of fitness. Darwin notes that like all things sexually selected for, music is ubiquitous. It

develops spontaneously and reliably in humans, and it elicits very strong emotions (Darwin, 1871). Miller (2000a, 2000b) extended Darwin's work, adding that anyone can learn a melody, that music seems to use a specialized memory capacity, that emotions are elicited not only in the production of music but also while listening to music.

There remains some debate in the field as to what fitness music may be exhibiting. Miller believes that the specific fitness that music indicates is fluid generalized intelligence or "fluid g" (Miller, 200b); others assert that emotional intelligence is being showcased by music (Kaufman et al., 2009). Generalized intelligence was conceived of as an underlying ability to explain variation in intellectual performance, such that differences across various domains of intelligence all boil down to a single factor "g" (Spearman, 1946). According to Spearman, variation among intellectual abilities could be explained by the 'g' factor, which he defined as 'energy' or 'power,' and which is common to all tests and a specific factor, which is unique to each test but also influences the overall assessment levels (Spearman, 1946). Later, Cattell (1967) introduced his theory that includes two factors: 1) crystallized general intelligence-- or one's ability to make skilled judgments that accounts for variations in learned material such as history or geography; and 2) fluid general ability—one's ability to reason quickly and think abstractly, which accounts for variation in problem solving, pattern recognition, and adaptation to new situations. The concepts of 'g' and "fluid g" share many features with Deacon's (2006) conceptualization of emergent systems effect (divergent thinking)¹ and Coolidge and Wynn's conception of a central executor (executive

¹ Deacon calls cognitive modernity an "emergent complex system effect" (Deacon, 2006, p. 29), meaning that modern cognitive abilities developed from the interplay between many augmentations to subservient neural systems. Deacon argued that "something more" arises out of human cognitive systems. Although many of the systems subservient to cognition can be identified inside the brain, the "something more"

functioning),² which have both been tied to the emergence of modern human cognition. All four refer to an ill-defined mental capacity enabling mental flexibility.

Trivers' (1996) theory of parental investment states that the sex making the largest investment of resources for nurturing and protecting offspring will be more discriminating in mating, and that the sex that invests less in offspring will compete for access to the higher investing sex. Female humans, because they produce a limited number of eggs and have a long gestational period, make a greater investment. Males on the other hand can replenish their gamet supply and return to the mating pool much sooner than women (Kokko, 2008). Therefore given equal amounts of males and females that are ready to mate (i.e., fertile), there will be more men “on the market” than women. In humans the operational sex ratio (OSR), of sexually competing males to females is high, or male-biased because of these limiting factors (Clutton-Broke & Vincent, 1991). Males are then forced to compete more intensely for access to mates, generating sexual selection for traits that increase male mating success (Kokko).

Given these investment contingencies, if music is a sexually selected trait, then we would expect mating-minded men to display musical ability more than women. Demographic data on the production of music reports that men produce 20 times as many jazz albums, 8 times as many modern paintings, and 3 times as many books as women (Miller, 1999). This finding might be an artifact of cultural norms, values, and

that emerges out of the interplay between these systems is uniquely human and unidentifiable.

² Coolidge and Wynn argue that the presence of a central executor integrating the dorsolateral frontal lobe, orbitofrontal area, and anterior cingulate gyrus is responsible for executive function and marks the onset of modern behavior (Coolidge & Wynn, 2005).

opportunities. Historically, it has been more socially acceptable for men to live the life of a musician than women.

A high OSR also creates variation in mating preferences and behavior among the sexes. In a short-term mating situation (one night stand) the parental investment is especially high for women and evidence shows that females desire and seek fewer short-term mates than males (Gangestad & Simpson, 2000). In long-term compared to short-term scenarios the parental investment is greater for men (although still highest for women) and therefore both sexes should be exhibiting their “good” genes. It has been shown that women particularly value trustworthiness and commitment when assessing a long-term mate (Haselton & Buss, 2000). In a study by Griskevicius, Cialdini, and Kenrick (2006), thinking about long term mating that included the traits of commitment and trustworthiness increased displays of creativity in both sexes, *but* when the participants were primed to think about short-term mating only the men showed increased in creativity.

Goals of the present study

The current study builds upon existing knowledge in the areas of sexual selection, parental investment, and mating preferences to explore three research goals. (1) Specifically, **we will investigate whether music is currently sexually selected for**. We will do so by examining differences in music production and musical ability between men and women by experimentally manipulating the degree to which men and women are thinking about short-term and long-term mating. If musical performance is sexually selected for it should be sexually dimorphic. We expect that men primed with a short-term

or long-term mating scenario will exhibit greater musical production skills than those who are primed with a neutral scenario. We expect that women primed with a long-term scenario will exhibit greater musical production skills than women in the short-term or neutral conditions. Finally we expect a significant difference between men and women after a short-term prime. We do not expect differences between men and women on ability.

(2) A secondary goal is to investigate if variables known to influence mating also affect musical production. There has been extensive research on what men and women find enticing, when, and why (see Buss & Mestlin, 2009 for a review). Some of these findings need to be considered in relation to the current study. It has been reported that when women are at the most fertile point in their cycle (ovulation) they prefer men who are more socially dominant (Gangestad & Thornhill, 1998), have more masculine faces (Penton-Voak & Perrett, 2000), have deeper voices (Puts, 2005) and are creative over wealthy (Haselton & Miller, 2006). These differences have not been found in women who are taking oral contraception. It has also been shown that anxiety and depression can augment sex drive in men and women (Mathew & Weinman, 1982; Garvey, 1985). Caffeine intake can affect arousal and mood, as shown in studies using various measures including skin conductance response, startle eyeblink reflexes, cardiovascular function, and the Bond and Lader (1974) mood scale (Mikalsen, Bertelsen, Flaten, 2001). We will gather information related to each of these variables (i.e., oral contraception, current mood, caffeine intake) to determine their impact (if any) on musical production and/or aptitude on participants in the current study.

(3) The third goal builds upon research (discussed above), which suggests that the specific fitness that music indicates is fluid generalized intelligence or “fluid g.” Given this finding, we are interested in looking at possible **underlying constructs of musical production specifically, IQ, divergent thinking and executive functioning**. We are interested in these constructs because they all relate to an ill-defined mental capacity enabling mental flexibility that may underlie differences in musical production.

General Methods

Participants

This study was approved by the Brooklyn College Institutional Review Board, and all participants provided written informed consent. Participants were recruited from the Brooklyn College Psychology Department's participant pool. Students received class credit for their participation. Participants were undergraduate students between the ages of 18 and 30; this age range was selected to maximize the probability of including participants for whom mating strategies were salient concerns. Women's fertility peaks between the ages of 22 to 26, and often declines after 30: a typical 30 year old woman has 12% of the ovarian reserve she was born with, and has only 3% at age 40 (Hamish, Wallace, & Kelsey, 2010). Participants with musical training were excluded because musical training would provide an unfair advantage for the production task. Musical training was assessed using the musical section of the Creative Achievement Questionnaire (Carson, Peterson & Higgins, 2005) anyone who marked a score above 0—"i.e., *I have no training or recognized musical talent,*" was considered musically trained. Although we explicitly stated that participants must be under 30 years of age and have no musical training, not all participants followed these instructions. Therefore, participants who showed up to scheduled appointments who were excluded because they were over age 30 or had musical training did not receive credit. Participants who withdrew without completing the study received credit without penalty.

A numbering system was used to maintain anonymity. Individual protocols were not linked to identifying information. Although IQ estimates were calculated, this study was

not designed to assess intelligence in an educational or clinical sense, and this information was not disseminated to participants. However, participants who reported clinically elevated levels of anxiety or depression i.e, Beck Depression Inventory (BDI-II) scores > 20; Beck Anxiety Inventory (BAI) scores > 16, were provided with a list of local psychological referral sources. Participants who reported clinically severe levels of depression or anxiety (BDI-II scores > 28; BAI scores > 26) were escorted to the clinical services on the first floor of the Psychology Department building directly after participating.

Materials

Mating primes. Participants read one of three mating primes created and shared by Griscivious, Cialdini, and Kenrick (2005). The short term mating prime encourages participants to think of the last day of a vacation on an island. On this last day, they meet a new romantic interest, and the story ends with the two lovers kissing passionately on a moonlit beach. In the long-term prime scenario, participants imagine themselves meeting someone on the university's campus and spending a wonderful afternoon and romantic evening with this person, including a candlelight dinner and a sweet kiss goodnight. The long-term scenario includes intended commitment: (1) the couple has been dating a while, (2) trustworthiness (the participant has met and likes the target's friends), and (3) the target was "good relationship material" (the target has met the participant's friends, and they approve). The long-term scenario belabors the idea that this person may be a good long-term partner and ends with the reader anticipating an "official" first date. Finally, in the neutral scenario, two same sex friends go to a much-anticipated concert. All three scenarios are approximately 850 words in length and have been shown to successfully

prime participants in a previous study on creativity (Griscivious, Cialdini, & Kenrick, 2005).

The Advanced Measures of Music Audiation (AMMA). The Advanced Measures of Musical Audiation (AMMA; Gordon, 1989) was used to assess musical aptitude, defined as the potential to hear, feel, and comprehend music that is innate and not affected by musical instruction (Gordon, 1989). The task was first developed to test children for inclusion (not exclusion) in musical instruction; the task has subsequently been revised to permit its use with high school and college students. The AMMA consists of 30 tests items each containing a pair of musical phrases lasting 12 to 14 seconds. The task is to determine if the pair of phrases is the “same” or “different.” If the two differ, participants are asked to indicate whether the difference is tonal or rhythmic. Each pair has the following options: same, differs in tone, differs in rhythm. Responses are recorded on a score sheet and scored using masks provided with the test.

Overall, research indicates that the AMMA is a reliable and valid measure of musical aptitude that measures an important component of musicality (Gordon, 1989). In a study investigating factors that underlie musical expertise, aptitude (measured by the AMMA) and IQ (measured by the Raven’s Progressive Matrices; Raven, Raven & Court, 2003) were identified as contributing significant variance to musical performance above and beyond hours of practice in high school (study 1) but not college conservatory orchestra members (study 2) (Ruthsatz, Detterman, Griscom & Cirullo, 2008). As measures of achievement, high school students were rank ordered on musical skill by their band instructors, while the college students were ordered on the basis of admissions scores for music majors (range 1 to 5; 5 being the most adept). In the first study a hierarchical multiple regression

found that IQ, AMMA, and practice time (hours of deliberate practice) accounted for significant amounts of variance in musical performance ($R^2 = .06$, $F(1, 174) = 11.95$, $p < .01$; $R^2 = .09$, $F(1, 174) = 8.97$, $p < .01$; and $R^2 = .18$, $F(1, 174) = 12.84$, $p < .001$, respectively). In the second study, IQ, the AMMA, and practice time did *not* contribute significant amounts of variance to musical performance. This notable difference may be the result of the restricted range (1 to 5) of the admissions scores used as the measure of achievement in the conservatory orchestra; a rank order from the conductor would have yielded a larger range. Another possibility is that the selected orchestra members were a biased sample because their scores fell at the upper end of the three measures. In support, the study did find that the orchestra sample had significantly higher scores than the high school students on IQ and musical aptitude tests. In either case, participants in the current study were non-music majors, and we therefore do not anticipate ceiling effects.

Further research by Ruthsatz, Detterman, Griscom and Cirullo (2008) provided evidence of convergent construct validity for the AMMA. As one would predict for a measure of aptitude, AMMA scores were significantly correlated with IQ (study 1, $r = .22$, $p < .01$ and study 2, $r = .35$, $p < .01$) and practice time (study 1, $r = .20$, $p < .01$ and study 2, $r = .51$, $p < .01$). An unpublished dissertation investigating the validity of the AMMA reported mixed findings (Fullen, 1993). When AMMA scores were compared to judges' ratings of choral performances both tonal and rhythmic aspects were modest ($r = .24$, $p > .05$ $r = .16$, $p > .05$, respectively). These finding may be an artifact of comparing an aptitude test with a choral performance task. The choral performance at the high school level might be a more accurate test of memory than musical ability. Fullen also found that scores on the AMMA

were correlated before and after musical instruction. High school students were tested at the beginning and end of the semester, and it was found that the tonal pre-post administration correlated at $r = .75$, the rhythmic at $r = .71$, and the combined scores at $r = .81$. These results suggest that the AMMA is testing a relatively stable trait.

Using a sample of 5,336 students from 54 institutions of higher education in 27 states, Gordon (1989) calculated split-half reliability coefficients for the AMMA. For non-music majors the tonal coefficient was $r = .80$, rhythm $r = .80$, and total $r = .80$ (Gordon, 1989). These coefficients indicated adequate internal consistency for the AMMA. To investigate test retest reliability, the authors asked university professors to administer the AMMA to 33 undergraduate music majors and 37 undergraduate non-music majors at a state university in Pennsylvania. They found that music majors had adequate test-retest coefficients for tonal $r = .86$, rhythm $r = .87$, and total scores $r = .89$ (Gordon). Non-music majors had test-retest coefficients for tonal of $r = .80$, rhythm $r = .81$ and total $r = .83$. These findings are generally consistent with the pre-post test results reported by Fullen (1993), and indicate good test-retest reliability as would be expected with a test of musical aptitude.

Delis-Kaplan Executive Function System (D-KEFS Design fluency subtest).

Executive functions are a group of cognitive processes that enable such higher order abilities as planning, cognitive flexibility, initiation of actions, and the overriding of automatic responses (Lezak, 1995). The Design fluency subtest from the Delis-Kaplan Executive Functions System (D-KEFS) uses the production of abstract novel designs to assess aspects of executive functioning including novel output, a tendency toward

perseveration, response inhibition, and cognitive flexibility (Delis, Kaplan, & Kramer, 2001). The task is comprised of three conditions. In the first condition participants are asked to draw as many designs as they can in 60 seconds, a test of design fluency. In the second condition participants are asked to draw as many designs as they can in 60 seconds by connecting the empty dots and ignoring the filled dots, a test of response inhibition. In the third condition participants must alternate between filled and empty dots while making as many designs as possible in 60 seconds, a test of cognitive flexibility.

Design fluency was standardized using a nationally representative, stratified sample of 1750 participants (age range 8 – 89). There were equal proportions of men and women in each age group, and the distributions of region and race closely paralleled the distributions reported in the 2000 census. Correlations between conditions were moderate. Each of the conditions was shown to contribute equal weight to the total composite achievement score (Delis, Kaplan & Kramer, 2001). Design fluency was further investigated as part of a study by Baldo, Shimamura, Delis, Kramer, and Kaplan (2001) investigating frontal lesions and performance on verbal fluency and category fluency. The researchers found differential performance on verbal fluency; left lesion patients performed significantly worse than right lesion patients, but right and left lesion patients performed equally poorly on design fluency. Therefore, unlike verbal fluency that relies heavily on left frontal lobes, design fluency seems to be equally affected by damage to either side of the brain. This finding is particularly important because this task is currently being used in a study of musical ability. Although the right/left distinction between music

and language oversimplifies the matter (see Brown, 2000), it is important that this measure of executive functioning does not appear subject to lateralization.

Other studies have investigated the relationship between design fluency and IQ yielding mixed results. One study found that children with heavy exposure to prenatal alcohol performed poorly on verbal fluency and design fluency tasks as compared to controls (Schonfeld, et al., 2001). Regression analysis showed that their variability in performance could not be explained by differences in IQ scores. In a study of patients with closed head injury and cognitively healthy adults, Varney and colleagues (1996) found no relationship, in either group, between the number of designs produced and IQ (WAIS-R; Wechsler, 1981), though Ruff (1987) found a modest correlation between performance IQ (WAIS-R; Wechsler, 1955, 1981) and design fluency in healthy adults. Both studies used the Ruff figural fluency test (RFFT) whose specific directions are to 'draw as many design as possible without producing a design that could be named, scribbled or repeated in 5 minutes'. Because of differences in test administration between the D-KEFS and Ruff versions of design fluency, the various findings cannot be compared directly. At present, the nature of the relationship between executive cognitive abilities and IQ requires clarification.

Divergent construct validity was investigated using a sample of 292 adults who were given the D-KEFS (including design fluency) and the California Verbal Learning Test, Second Edition (CVLT-II; Delis, Kramer, Kaplan, & Ober, 2000), an episodic memory test. As expected, most design fluency scores were not correlated with CVLT-II scores. Small, positive correlations were found among the design fluency switching condition and

delayed memory scores. This finding might be the result of overlap between the cognitive processes necessary for a memory search and an executive function task. The cognitive processes activated during a fluency task can be conceptualized as a “memory search” that involves the use or active restriction of associations (Butler, Rorsman, Hill & Tuma, 1993). According to Butler and colleagues, searching for a previously learned word or searching for a previously drawn design both make use of search strategies, the better the search strategy the better the result (as long as memory stores are intact). Therefore it may be that the positive correlation found with the CVLT-II is indicative of the overlapping variance of searching.

Convergent construct validity was investigated by comparing design fluency with a well-known test of executive functioning, the Wisconsin Card Sorting Test (WCST; Heaton, Chelune, Talley, Kay, & Curtiss, 1993). The WCST taps various executive cognitive processes including strategic planning, organized searching, utilization of environmental feedback to shift cognitive sets, directing behavior toward achieving a goal, and modulating impulsive responding. The WCST has proved sensitive to frontal dysfunction in the dorsolateral prefrontal cortex of rhesus monkeys (Baxter, 2009) and the frontal lobes of humans (Robinson, Heaton, Lehman, & Stilson, 1980). Delis, Kaplan and Kramer (2001) reported that the number of completed categories on the WCST correlated at $r = .35$ with design fluency, and perseverations correlated $r = -.36$ in a group of 22 adults. The results indicated modest relationships, in the expected directions, between design fluency and the WCST.

Research has also indicated that design fluency is a reliable measure. Test-retest reliability was calculated in 101 participants who undertook the test at two time intervals (average of 25 days apart). Results revealed that participants improved from test time 1 to test time 2, with the exception of number of repetition errors (Delis, Kaplan & Kramer, 2001). Internal consistency cannot be determined on this task because it is a time sensitive measure with three interdependent conditions.

Raven's Standard Progressive Matrices (Raven's). The Raven's was originally designed to measure Spearman's 'g'. The concept of 'g' can be understood as an underlying cognitive ability, such that people who do well on one type of cognitive/ability test often do well on other types of tests. In 1951 Spearman agreed that the test did measure 'g' (Spearman & Wynn-Jones). Horn (1994), a supporter of the fluid/crystallized distinction, has stated that the Raven's is one of the purest measures of fluid intelligence. Since Spearman's endorsement, there has been a debate over whether the Raven's test is a pure test of g, or whether it also measures spatial ability. Emmett (1949) concluded that the Raven's is a pure measure of 'g' based on a factor analysis of the items in a sample of 11-year-olds. Jensen (1998) strongly agreed stating that 'the total variance of Raven's scores in fact comprises virtually nothing besides 'g' and random measurement error' (p. 541). Raven, Raven, and Court (2000) based on factor analyses, stated that 'the Progressive Matrices has been described as one of the purest and best measures of g or general intellectual functioning' (p. 34). Research supports these statements; in the U.S., a 'g' loading of .81 was reported in children (Zagar, Arbit, & Friedland, 1980), and another study found 'g' loading as high as .94 in adults (Crickmore, 1968).

Conversely, some studies have reported much lower loadings and multiple factors such as Keir (1949), who found that 'g' was only responsible for 37% of the total variance of the scores on the Raven's, and a series of studies have found evidence for a separate factor for spatial ability. Sinha (1970), for example, found that Indian students studying architecture (and other subjects that train spatial abilities) score higher on the Raven's than students in other fields. The observation could be made that spatial ability and 'g' are closely linked, and that students with higher 'g' loadings are more interested in subjects that exploit this link. Put another way, it might be that architecture students have higher scores on the Raven's even before they decide to study architecture. Overall, while the Raven's may not be a pure measure of 'g,' available evidence suggests that it is a very good measure.

In terms of convergent validity, studies on the correlation between the Raven's and various versions of the Wechsler Adult Intelligence Scales (WAIS; Wechsler, 1955; WAIS-R; Wechsler, 1981) have produced a variety of results. Bingham, Burke and Murray (1966) reported $r = .85$ and Burke and Bingham (1969) reported $r = .75$ between the Raven's full scale WAIS. O'Leary (1991) reported a correlation of $r = .74$ between Raven's and the full scale WAIS-R for adults aged 16-24 and $r = .77$ for adults aged 24-34. Additionally, 3,000 psychiatric patients from a Veteran's Administration hospital showed a correlation of $r = .66$ between the Raven's and the full scale IQ of the WAIS and a correlation of $r = .65$ with performance IQ (Burke, 1985). Because the concept of 'g' is understood as the common denominator for individual differences, divergent validity tests are inappropriate and not reported for the Raven's.

A typical split-half reliability for the Raven's is $r = .86$, although lower values are generally found with younger subjects (Raven, Raven, & Court 2003). Burke reported a series of split-half reliability values ranging from .89 to .97, depending on age, in a sample of over 500 U.S. adults. Burke (1972) concluded that the 'corrected split-half reliability for Raven's scores was better than the corrected split-half reliability for WAIS performance scores' (p. 255). Test-retest reliability for adults has ranged from .80 to .93, over one-week, and one-year. Test-retest reliability is less impressive for young children, but after the age of 14 is typically reached; scores on the Raven's remain relatively constant for about 10 years (Slater, 1947).

The Abbreviated Torrance Test for Adults (ATTA). The Abbreviated Torrance Test for Adults (Goff & Torrance, 2002) was developed to assess creative ability through the completion of three activities. In this study, we used activity one, which requires respondents to pretend that they can walk on air or fly and then identify the "troubles" they might encounter. Each respondent has 3 minutes to state as many possible troubles as possible. The scoring criteria focus on four norm-referenced abilities; *fluency* – the number of relevant ideas; *originality* – the number of statistically infrequent ideas. The abilities can be normalized individually resulting in two interpretable and comparable scores. The ATTA has been the most extensively used test of divergent thinking with over 2000 studies reporting its use as of 2002 (Davis, 1977; Lissitz & Willhoft, 1985).

Construct validity was investigated by comparing the ATTA subscales to the spatial test of primary mental abilities (Thurstone & Thurstone, 1989) and Gordon's test of visual imagery control (Richardson, 1969). Results revealed statistically significant correlations

between originality (of the ATTA) and the spatial test of primary mental abilities ($r = .36$) and Gordon's test of visual imagery control ($r = .30$) (Gonzalas & Campos, 1997).

Furthermore, across 50 studies investigating the validity of the ATTA, only one had concerns about the predictive validity of the test (Holland, 1961). Reliability for the ATTA has been studied using the Kuder-Richardson's formula 21 (KR-21), which is equivalent to the mean of all possible split-half coefficients for a given test. This test is used when items are dichotomous (0 or 1), and all items are of equal difficulty. Torrance (1984) reported KR-21 values of .45 for fluency, .38 for originality, .84 for elaboration, .38 for flexibility, and .69 for the total indicating reasonable item consistency. In a review, Holland (1961) reported that 15 studies have investigated test-retest reliability and the majority of these coefficients have exceeded $r = .70$.

Musical Production Task. This novel task was designed to assess the ability to create a piece of original music within a designated time frame. Cross and Morely (2009) discussed the great many potential definitions for music. We will adapt their definition of music broadly as "embodying, entraining, and transposably intentionalizing time in sound and action, typically expressed by voices and instruments that articulate patterns in pitch, rhythm and timbre, and involving correlated gestural patterns of movement that may or may not be oriented towards sound" (Cross & Morley, 2009, pg. 61). In phase one of the current study, participants were asked to spend four minutes creating an original piece of music that was 30 seconds in duration on a toy xylophone. Once the four minutes had passed, participants were asked to record their piece of music using GarageBand, a software application that allows users to create music. A wooden toy xylophone was

chosen because of its restricted range (five notes) and non-traditional chromatic scale (c, d#, e, g, a^b).

In the second phase of the experiment, 82 raters of both sexes rated the pieces using the using the *musical evaluation survey* (adapted from Kozbelt & Serafin, 2009) The original scale, *artistic evaluation survey*, was used to asses artistic works and included the following dichotomous variables: interesting/uninteresting, detailed/vague, very unusual/ not usual, very meaningful/not meaningful, very realistic/not realistic, very strong/not strong very beautiful/not beautiful, high technical skill/low technically skill, very orderly/not orderly, very abstract/not abstract, very appealing/not appealing, very complex/ not complex, this world/otherworldly, and high quality/ low quality (Kozbelt & Serafin, 2009). This scale was augmented to apply to music. Items that translated well to the musical domain were kept and items specific to music were added (described below). The *musical evaluation survey* includes the following bipolar items to be rated on a scale from 1 to 8: Low Quality/High quality, Unappealing/Appealing, Expressionless/Expressive, Unimaginative/Imaginative, Simple/Complex, Dull Rhythm/Interesting rhythm, Dull melody/Interesting melody (Appendix A).

A pilot study employing the xylophone production task was carried out. Three participants were excluded because of musical training and one exceeded our age range. The final sample consisted of 18 participants (4 males, 14 females, aged 19 to 30). The participants were read the following directions:

“We are interested in people’s ability to create interesting and novel pieces of music using a xylophone. It does not matter whether or not you have musical

experience. What I would like you to do is create a song on this xylophone. There are 5 notes (demonstrate). Please spend the next 4 minutes creating a 30 second piece of music. Once the four minutes have lapsed you are to record the 30 second creation by pressing this button. Your piece of music will later be rated by a group of males / females (the opposite of what they are) on items like originality, expressiveness, quality, and if it provokes imagination. Do you have any questions?"

All participants completed the task in a sound proof chamber to decrease distraction, increase the quality of the recording, and provide privacy. Recording utilized a streamlined digital audio workstation (DAW) and music sequencer, which can record and play back multiple tracks of audio called GarageBand. The program was run on a MacBook using Core 2 Duo processor and the GM965 chipset, with Intel's GMA X3100 integrated graphics on an 800 MHz system bus. Sounds were imported into GarageBand using the blue snowball microphone, an electret condenser microphone that is responsive to bandwidths between 40-18000 Hz. Participants were taught how to use the recording device prior to the test phase so they were not interrupted. All participants in the pilot study successfully recorded 30 seconds of music, completed a basic demographic questionnaire, and completed the music portion of the creative achievement questionnaire (Carson, Peterson & Higgins, 2005). The 18 recorded pieces were then transformed into mp3's using GarageBand and iTunes, and any music past 30 seconds was deleted to keep the lengths uniform; subsequently, the mps's were made into a playlist. Participants very rarely went over the 30 second mark, when they did it was usually by approximately 2 seconds.

In the second phase of the pilot study, two graduate students and one research assistant rated the music using the *musical evaluation survey* (described above). To ensure that the musical production task and the *musical evaluation survey* were suited for use with a population of non-musical undergraduate students, we conducted preliminary analyses of normality, internal consistency, and inter-rater reliability.

Skewness and kurtosis were calculated on the average ratings (collapsed across the three raters for each of the 14 items) for each composition to investigate possible ceiling or floor effects. The distribution was approximately normal (skewness = .06, standard error = .23), and showed normal kurtosis (kurtosis = -.82, standard error = .99). To test for internal consistency of the *musical evaluation survey*, we calculated alpha across all items yielding $\alpha = .96$, indicating that the measure is assessing a single underlying construct. A final analysis investigated inter-rater reliability between raters using means for each composition. Cronbach's alpha was .58, indicating an adequate relationship between raters for an exploratory study.

Together these findings suggest that the musical production task displays sufficient variability to be used as a measure in a non-musical sample. Additionally the *musical evaluation survey* appears to measure a single underlying construct and different raters generally agreed on the differences between compositions. We expected that inter-rater reliability would be improved in the larger study (see below), as the number of raters and number of compositions would be increased. Additionally, although inter-rater reliability should be very high for *objective* neuropsychological measures, in this study we were looking at people's *subjective* ratings of music, so we were not expecting the same level of

agreement.

Questionnaires and demographics.

We also gathered information on variables thought to affect performance on musical and neuropsychological tasks. The demographic sheet (developed in our lab) included information about age, sex, race/ethnicity, years of education, grade point average, sleep, caffeinated beverages consumed on the day of the testing, female ovulation cycle for female participants (first day of last period, and birth control use), and years of musical training (adapted from the creative achievement questionnaire (Carson, Peterson & Higgins, 2005) (see Appendix B). The demographic sheet also included mating preferences (adopted from Buss & Schmitt, 1993), which included questions like: *How many sex partners would you ideally like over your lifetime?; How likely would you be to have sex with a desirable partner if you had known him/her for one hour (0% chance to 100% chance), one day, one week, one month or one year.* We also asked to what extent (0% to 100%) were participants seeking a short-term versus a long-term mate. Anxiety was measured by the Beck Anxiety Inventory (BAI, Beck & Steer, 1993), a 21-item measure of symptoms such as numbness, hot and cold sweats, or feelings of dread. The BAI has been found to reliably discriminate anxiety from depression while displaying convergent validity (Beck & Steer). Depression was measured using the Beck Depression Inventory, Second Edition (BDI-II, Beck, Steer, & Brown, 1996) a 21-item multiple choice, self-report inventory. The items assess depression symptoms such as hopelessness and irritability, cognitions such as guilt or feelings of being punished, as well as physical symptoms such as fatigue, and lack of interest in sex. The BAI and the BDI-II are among the most widely used self-report measures of emotional functioning and there

is strong support for their reliability and validity with young adults (Arnau, Meagher, Norris, & Branson, 2001; Carmody, 2005; Osman, Kopper, Barrios, Osman, & Wade, 1997).

Procedure

The order of task administration is presented in Appendix C. All participants were tested by one of five researchers, one of whom was pregnant. Upon entering the lab, participants read and signed the informed consent form (Appendix D). After signing, the experimenter assigned a number to each participant and randomly assigned group membership (long-term, short-term, or neutral condition). We then collected information on variables thought to affect performance on the tasks, mating strategies, or musical behavior including: female ovulation cycle, sleep quality, and caffeinated beverages consumed; factors known to affect effort such as anxiety, and depression; variables that might interact with the production or assessment of music such as years of musical training; and standard demographic data prior to beginning the tasks.

Participants were then escorted downstairs to a sound proof chamber where they read a neutral, short-term mating, or long-term mating vignette created by Griscivous et al. (2005) before completing tasks. All vignettes are included in Appendix E and had the following directions at the top of the page: *Instructions: Please carefully read the following scenario. As you're reading the scenario, try to put yourself in the shoes of the main character and experience the emotions that he/she is feeling.* Participants then indicate the extent to which they experienced sexual and romantic arousal on a 7-point scale (1-not at all to 7-very much).

Next, participants were instructed to create a novel piece of music on a xylophone.

Participants were read the following instructions:

“Thanks so much for volunteering to participate in this study, we really appreciate it. What I would like you to do is create a song on this xylophone, there are 5 notes (demonstrate). You will have 4 minutes to create a novel and interesting piece of music. Once the 4 minutes have lapsed, we will record you using this microphone.

Your piece of music will later be rated by a group of males/females (the opposite of what they are) on quality, originality, appealingness, expressiveness and if it provokes imagination. Do you have any questions?”

The experimenter then explained how to record a piece of music.

“Once your 4 minutes have elapsed, press this button to start recording, and press the space bar to stop. The piece of music should be about 30 seconds long; you can track how long your piece is by looking here (point). If you would like to time your pieces you can use this stop watch”.

All participants completed the task in a sound proof chamber to decrease distraction, increase the quality of the recording, and provide privacy. Recording was done using a streamlined digital audio workstation (DAW) and music sequencer, which can record and play back multiple tracks of audio called GarageBand. The program was run on a MacBook computer using Core 2 Duo processor and the GM965 chipset, with Intel's GMA X3100 integrated graphics on an 800 MHz system bus. Sounds were imported into

GarageBand using the blue snowball microphone, an electret condenser microphone that is responsive to bandwidths between 40-18000 Hz. Participants were taught how to use the recording device prior to the test phase so they were not interrupted. The 92 recorded pieces were checked for quality and then transformed into mp3's using GarageBand and iTunes, and any music past 30 seconds was deleted to keep the lengths uniform; subsequently, the mps's were made into a playlist.

After completion of the xylophone task, participants were escorted into a third room to complete a series of neuropsychological and musical ability tests in accordance with standard administrations procedures. Tests were always administered in the same order. First, executive functioning was measured using the D-KEFS design fluency task, followed by 'g' using the Raven's, and divergent thinking using the ATTA. Finally, after a priming booster, men and women in control, short-term primed, and long-term primed conditions completed the AMMA, a test of musical ability.

The purpose of the priming booster was to remind participants about the vignettes they read earlier. Participants who read the short-term or long-term mating prime were instructed to write for 3 minutes about the physical characteristics of the person in the story. Participants who read the neutral prime were asked to write about the physical characteristics of the concert venue.

When participants had completed the study, we thanked them for their time and explained that the purpose of this study was to better understand how music, mating, and various cognitive processes interact; subsequently we answered any questions about the tests or testing materials.

In phase two of the study, 84 other college aged men and women rated the musical pieces created in phase one on the following variables: Low Quality/High quality, Unappealing/Appealing, Expressionless/Expressive, Unimaginative/Imaginative, Without Rhythm/Rhythmic, No melody/Melodic. Raters were tested in groups using Qualtrics, an online survey based product. Demographic information was included on the Qualtrics survey so that sex, years of musical training, and mating preferences could be entered into the analysis. Before rating the pieces the experimenter played examples of pieces that would be rated as low (1) and high (8) for each of the above variables. Then participants rated all 92 pieces. They were encouraged to take breaks when needed. To encourage students to stay attentive, the experimenter asked each participant how he/she was finding the experiment. Qualtrics enables random presentation of the pieces, so that each participant received a randomly ordered set.

Predicted Study Results

Primary Hypotheses: Sex and Priming Effects on Musical Production and Aptitude. If music is a sexually selected trait, then we would expect mating-minded men and women to *display* musical ability more depending on the degree to which they are thinking about short-term and long-term mating. If musical ability is a way to showcase underlying fitness then, similar to the findings by Griskevicius, Cialdini, and Kenrick (2006) on creativity measures, we expect to see differences between the sexes on measures of

musical performance. We would not predict an overall difference in aptitude, because in line with mating theory, we expect differences in genetic *displays* rather than underlying ability. Men and women should have similar musical ability, but we expect them to show off this ability differently as a result of mating primes. Conceptually, some amount of shared variance is expected between IQ and musical performance (as measured by musical ratings) and aptitude (as measured by the AMMA). In fact, IQ and aptitude (as measured by the AMMA) have been shown to contribute separate and significant amounts of variance to musical performance (Ruthsatz, Detterman, Griscom & Cirullo, 2008). Therefore, once any shared variance is accounted for, differences between groups and across the sexes on musical production but not musical aptitude should be found.

H1: Men primed to think about short-term or long term mating will have higher ratings on the musical production task than men in the neutral condition.

H2: Women primed to think about long term mating will have higher ratings on the musical production task than women in the short-term or neutral conditions.

H3: Men primed to think about short-term mating will have higher ratings on the musical production task than women in the short-term mating condition.

We do not expect to find any sex or group differences on measures of musical aptitude.

Findings for these hypotheses would provide support for the idea that music is currently sexually selected for.

Influences of Variables Known to Affect Mating. There has been extensive research on what men and women find enticing, when, and why (see Buss & Mestlin, 2009

for a review). Some of these findings warrant consideration in relation to the current study.

Female humans, because they produce a limited number of eggs and have a long gestational period, make a greater investment in parenting. Males, on the other hand, can replenish their gamet supply and return to the mating pool much sooner than women (Kokko, 2008). Therefore given equal amounts of males and females that are ready to mate (i.e., fertile), there will be more men “on the market” than women. In humans the operational sex ratio (OSR), of sexually competing males to females is high, or male-biased because of these limiting factors (Clutton-Broke & Vincent, 1991). A high OSR also creates variation in mating preferences and behavior among the sexes. Therefore, we calculated average musical rating scores for the musical pieces separately for male or female raters. Using the new variables (average musical rating by female raters and average musical rating by male rates), mating prime and sex differences were investigated. Differences between groups and across the sexes on musical production ratings by females and musical rating by males were expected.

Women at the most fertile point in their monthly cycle (ovulation) have been shown to prefer men who are more socially dominant (Gangestad & Thornhill, 1998), have more masculine faces (Penton-Voak & Perrett, 2000), have deeper voices (Puts, 2005), and who are creative over wealthy (Haselton & Miller, 2006). These differences have not been found in women taking oral contraception. Participants in our study were asked if they were taking any form of birth control. They were also asked to report the first day of their last menstruation. It has also been shown that anxiety and depression can augment sex drive in

men and women (Mathew & Weinman, 1982; Garvey, 1985). Caffeine intake can affect arousal and mood, as shown in studies using various measures including skin conductance response, startle eyeblink reflexes, cardiovascular function, and the Bond and Lader (1974) mood scale (Mikalsen, Bertelsen, Flaten, 2001). An individual's current mating situation (whether a person is seeking a short-term or long-term partner) and ideal number of partners, have also been shown to affect mating. Each of the related variables (i.e., ovulation, mood, caffeine intake, mating situation, and number of ideal mates) was entered as a covariate in our univariate analyses (i.e., hypotheses H1, H2, and H3) to determine each variable's impact (if any) on musical production and aptitude.

H4: This exploratory hypothesis investigated whether the overall pattern of results for H1-H3 significantly changed as a result of the relevant covariates of ovulation, caffeine intake, current mating situation, number of ideal mates, and mood.

Underlying constructs of musical production. An additional study goal builds upon research suggesting that the specific fitness that music indicates is fluid generalized intelligence or "fluid g" (Miller, 2000a, 2000b). Given this finding, we were interested in looking at possible underlying constructs of musical production-- specifically IQ, divergent thinking, and executive functioning. Each of these constructs relates to an ill-defined mental capacity enabling mental flexibility that may underlie differences in musical production. We aimed to understand whether mental flexibility, operationalized in the current study as IQ measured by the Raven's, divergent thinking measured by the ATTA, and executive functioning measured by design fluency, was related to the production of a novel musical piece.

H5: This hypothesis investigated whether a significant amount of variance in musical ratings would be explained by IQ, divergent thinking, and/or executive functioning.

Finally, we were interested in whether the mating primes and sex differentially affected subtypes of mental flexibility (operationalized in the current study as IQ measured by the Raven's progressive matrices, divergent thinking measured by the ATTA, and executive functioning measured by Design Fluency).

H6: This hypothesis investigated whether mating primes and sex affected performance on measures of IQ, divergent thinking, and executive functioning.

Results

Overview of Analyses

Degrees of asymmetry and peakedness in the distributions of all variables were evaluated by calculating skew and kurtosis statistics, applying cutoff values recommended by Tabachnick and Fidell (1996). Before addressing our primary hypothesis a few confirmatory analyses were conducted. First, to determine if reading short-term, long-term, or neutral vignettes primed participants to be differentially aroused, two separate ANOVAs on the self report arousal questions were performed. We then investigated the effect of arousal on musical performance conducting ANOVAs for each sex independently. Next we examined correlations between performance and 'g'. Finally, we investigated if a visibly pregnant experimenter differentially primed participants, by conducting a t-test on performance. For the primary analyses, the musical production composite scores and scores on the AMMA were analyzed as dependent variables in a MANOVA with vignette group (neutral, short-term, long-term) and sex (male, female) as between subjects factors. Then, planned contrasts were performed for a priori group comparisons (hypotheses H1 to H3). The same analyses were repeated excluding eight participants who were suffering from psychological distress at the time of the evaluation (described below). Then we repeated the MANOVAs with mood, ovulation, mating strategies, and caffeine intake as covariates (H4). A follow-up analysis investigated the effects of sexual and romantic arousal on performance across the three mating conditions, broken up by sex. Next, musical production ratings were regressed on IQ (measured by the Raven's progressive matrices), divergent thinking (measured by the ATTA), and executive functioning (measured by Design Fluency) (H5). Finally, we investigated if our mating primes affected

performance on measures of executive function, IQ, and divergent thinking using a MANOVA (H6).

The significance level was set at $p < .05$, two-tailed, for all hypothesis testing procedures. Effect sizes, in the form of Cohen's d , were reported for all planned contrasts. Effect sizes, in the form of eta squared (η^2), were reported for all other analyses.

Demographics and Descriptive Statistics

Students were recruited from the Brooklyn College Psychology participant pool for Part I of the experiment and subsequently assigned to groups. Students participated to fulfill course requirements in psychology or receive extra course credit. In total 92 (45 male) participants completed the first part of the experiment (48.9% Caucasian, 29.3% African American, 7.6% Asian, and 7.6% other, 6.5% Hispanic). One participant was excluded because he suffered from bipolar disorder and felt it may have influenced his performance. Two participants reported having a diagnosis of Attention Deficit Hyperactivity Disorder (ADHD), one participant reported suffering from anxiety and depression, and one reported suffering from anxiety. In addition, one participant scored in the severe range for anxiety and depression, two participants scored in the severe range for anxiety, and one scored in the severe range for depression (as measure by the BAI and BDI-II). Participants who tested in the moderate range on these measures were given a list of local mental health referrals. Participants who scored in the clinically significant range for depression or anxiety were escorted to psychological services for follow-up. As a cautionary measure, participants who tested or reported clinically significant levels of depression or anxiety were asked whether they felt their anxiety or depression had

affected their performance; all six responded 'no'. Nonetheless, as mood disturbance can impact level of concentration and performance on creative (Green & Noice, 1988) and cognitive (Clore & Huntsinger, 2007) tasks, analyses were carried out with and without this small subgroup of participants with ADHD and affective distress (n=8) with no significant change in the overall pattern of findings (as shown below).

No participant reported having training or recognized talent in music, as measured by the Carson music scale (Carson, Peterson, & Higgins, 2005, see Appendix B). ANOVAs indicated that participants did not significantly differ by vignette priming group with regard to age, $F(2, 89) = 1.345, p = .266$, education³, $F(2, 87) = 2.403, p = .096$, or grade point average⁴ (GPA), $F(2, 85) = .283, p = .754$.

We also examined group differences on mating strategies. Participants were asked to indicate on a scale from 0% to 100% if they were currently seeking a short-term or a long-term mate. ANOVAs confirmed that the groups not differ with regard to vignette types for short-term, $F(2, 85) = .258, p = .733$, or long-term, $F(2, 85) = 1.197, p = .307$, mating strategies. The groups did display a main effect for sex when asked about short-term mating practices, $F(1, 85) = 5.377, p = .023$ with males seeking a short-term mate to a higher degree than women, but not for long-term mating practices, $F(1, 85) = .006, p = .937$ ⁵. Finally, chi square analysis revealed that the groups did not differ significantly by sex, $\chi^2(1) = .032, p = .847$. Participant demographics and mating strategies from Part I of the

³Two participants in the neutral group did not indicate their level of education.

⁴Four participants (two in the neutral, one in the short-term and one in the long-term) did not report their GPA.

⁵One participant failed to indicate the extent to which he was looking for a short-term or long-term mate; results based on 91 people.

study are displayed in Table 1. Participants were not screened for sexuality so we do not know how many homosexual, bisexual, or transgendered individuals participated.

Raters in Part II of the study were also drawn from the Psychology participant pool. Raters who participated in the first part of the study were not eligible for Part II. In total 82 (23 male) undergraduates rated the musical pieces created in the first part of the study (41.5% Caucasian, 20.5% African American, 14.6% Asian, and 9.8% other, 13.4% Hispanic). The demographic information for Part II participants was similar to participants in Part I, and is displayed in Table 2. In addition raters were asked if they were seeking a short-term or long-term mate on a scale from 0% to 100%. Mean percentages and standard deviations are also displayed in Table 2.

Skew and kurtosis statistics were calculated for all variables derived from the musical rating scores, D-KEFS design fluency test, Raven's, AMMA, and ATTA tasks and are displayed in Table 3. Musical rating averages were calculated across all 82 raters for the following seven dichotomous variables: Low Quality/High quality, Unappealing/Appealing, Expressionless/Expressive, Unimaginative/Imaginative, Simple/Complex, Without Rhythm/Rhythmic, No melody/Melodic. All musical rating variables were normally distributed.

A principle component analysis on the ratings was preformed to investigate the general underlying structure of the rating scale. The seven dichotomous variables were submitted to principle component analysis using the correlation matrix with no rotation. Only the first component had an eigenvalue greater than one, which confirmed one factor accounting for 80.45% of the variance. Therefore the seven dichotomous variables were

averaged into a musical production composite score that will be used in the remainder of analysis. Analyses for the main hypothesis were also conducted on the seven individual scores, reported in Appendix E and the general pattern was the same.

For the D-KEFS Design Fluency task, total design scores for each of the three conditions were computed (DF1, DF2 and DF3). Total raw score (i.e., number of correct answers) on the Raven's Progressive Matrices test and did not deviate from normal. Six variables were calculated for the Advanced Measures of Musical Audiation (AMMA): (1) tonal raw score and (2) corresponding tonal percentage; (3) rhythmic raw score and (4) corresponding rhythmic percent; and (5) total raw score and (6) total percent. All six AMMA variables were normally distributed.

Four variables were created from the Abbreviated Torrance Test for Adults (ATTA): (1) number of responses or fluency; (2) scaled score for fluency; (3) number of original responses or originality; and (4) scaled score for originality. All ATTA statistics deviated from normal. Specifically, the number of responses, or Torrance fluency, was positively skewed, and the scaled score for fluency was positively skewed and leptokurtic. The originality score on the ATTA was also positively skewed and leptokurtic. Therefore, a Kruskal-Wallis test was conducted on these variables. A correlation matrix displaying correlations for primary measures can be found in Table 4.

Primary hypotheses: Sex and priming effects on musical production and aptitude

Primary hypotheses related to the effects of priming and sex on musical production and aptitude after controlling for level of intelligence. Our first step was to confirm the

effectiveness of our primes. We then considered the direct effect of arousal on musical performance. We subsequently investigated the contribution of IQ to the variance of the musical rating and IQ. We then examined the effect of a pregnant tester on performance. Next, we calculated MANOVAs (as described above) followed by planned contrasts and then post hoc analyses. The groups utilized in these analyses were: (Vignette (short-term, long-term and neutral) by Sex (male, female)). As discussed by Cohen (2008), contrasts are permissible for the number of groups minus one, in this case that would be six groups, and five contrasts.

To investigate if arousal affected performance across the three mating conditions we first determined if reading short-term, long-term, or neutral vignettes primed participants to be differentially aroused. To investigate the effectiveness of the primes we carried out two separate ANOVAs on our self reported arousal questions. The dependent variables were the extent of sexual arousal and romantic arousal reported on a 7point scale (1-not at all to 7-very much). A significant difference was found for romantic arousal $F(2, 89) = 36.451, p < .001, \eta_p^2 = .45$. Tukey's honest significance test confirmed that participants' romantic arousal in the neutral condition ($M = 1.68, SD = .30$) was significantly lower than sexual arousal in the short-term ($M = 4.97, SD = .30, p < .001$), and long-term conditions ($M = 4.59, SD = .30, p < .001$). No difference was found for romantic arousal between the short-term and long-term conditions. A significant difference was also found for sexual arousal $F(2, 89) = 34.09, p < .001, \eta_p^2 = .43$. Tukey's honest significance test confirmed that participants' sexual arousal in the neutral condition ($M = 1.2, SD = .24$) was significantly lower than romantic arousal in the short-term ($M = 3.93, SD = .23, p < .001$,

and long-term conditions ($M = 2.38$, $SD = .23$, $p = .002$). Sexual arousal in the long-term condition was significantly lower than arousal in the short-term condition ($p < .001$). Taken together these results confirm that the vignettes had the desired effect.

A 2 (sexual arousal: high, low) X 2 (sex: male, female) X 3 (vignette group: neutral, short-term, long-term) between subjects ANOVA was conducted on musical performance. Sexual arousal was assessed with a 7 point scale and divided into low sexual arousal (a score of 1, 2, or 3) and high sexual arousal (5, 6, or 7) groups, with participants who responded at the midpoint of 4 being excluded from the analysis. The low arousal group had a total of 42 (18 female, 24 male) participants. The high sexual arousal group had a total of 45 (28 female, 17 male). Both females and males did not significantly differ in musical performance based on sexual arousal.

A 2 (romantic arousal: high, low) X 2 (sex: male, female) X 3 (vignette group: neutral, short-term, long-term) between subjects ANOVA was conducted on musical performance. Like the first analysis, scores on the romantic arousal scale were divided into low romantic arousal (a score of 1, 2 or 3) and high romantic arousal (5, 6, or 7) groups. Participants who responded at the midpoint of 4 on the romantic arousal questionnaire were excluded from analysis. The low arousal group had a total of 65 (32 female, 33 male) participants. The high romantic arousal group had a total of 17 (11 female, 6 male). Results indicated no significant differences for males or females. Mean romantic and sexual arousal ratings are plotted by group in Figures 5 and 6.

A Pearson correlation coefficient was calculated to determine if variation in 'g' was related to the musical ratings or measures of the AMMA. No significant correlations were

found between the Raven's progressive matrices and musical ratings or AMMA scores. Given that no significant correlations were found, it was unnecessary to control for the variation in Raven's scores in subsequent analyses. Table 5 presents the results of these correlational analyses.

The effects of a visibly pregnant tester on participants' performance was also investigated. A 2 (sex: male, female) X 3 (vignette group: neutral, short-term, long-term) between subjects ANOVA was conducted on musical performance using pregnant experimenter (pregnancy: visibly pregnant, not pregnant) as a covariate. Pregnant women begin to show between 18 and 20 weeks, although there is substantial variation. To be on the safe side we deemed any testing after her 18th week to be visible to participants. In total 18 participants (4 in the neutral, 5 in the short-term and 9 in the long-term) were tested by a visibly pregnant women, 74 participants were tested before the pregnancy was visible or by another experimenter. There were no significant effects of a visibly pregnant experimenter $F(1, 85) = .938, p >.05$.

ANOVA was performed on the composite musical rating to test the effects of mating primes and sex on the creation of a novel piece of music. For this set of analyses the musical production composite scores for all 82 raters were used.⁶ Univariate tests revealed a significant main effect of sex for composite musical ratings $F(1, 86) = 3.261, p = .050, \eta_p^2 = .044$. Men's musical pieces were rated as better than female's (male = 3.91 > female = 3.54). There was no significant main effect for mating primes and no significant

⁶ Additional analyses are included in appendix F using each of the seven dichotomous variables instead of the composite score.

interaction. Composite musical rating means and standard deviations by mating prime and sex are displayed in Figure 1.

We re-ran this ANOVA excluding the eight participants who reported or suffered from mood disorders and the results remained the same. Univariate results on the composite musical ratings indicated a main effect of sex $F(1, 78) = 4.796, p = .032, \eta_p^2 = .058$, but not for mating primes, $F < 1$.

A MANOVA was performed on the AMMA to test the effects of mating primes and sex on musical aptitude. For this set of analyses all six AMMA measures were used. The overall multivariate test (Wilks' Lambda) was not significant $F(12, 162) = .904, p = .748, \eta_p^2 = .049$. Results indicated no main effects of sex, no main effects for vignette type, and no interactions. Means and standard deviations by mating prime and sex are displayed in Figures 2 – 4. This MANOVA was also re-run excluding the eight participants reporting or suffering from a mood disorder. Again, the overall multivariate test (Wilks' Lambda) was not significant $F(12, 146) = .734, p = .716, \eta_p^2 = .057$, and there were no significant main effects, or interactions..

To investigate if mating primes had specific effects on musical performance or musical aptitude, planned contrasts were conducted comparing group means for composite musical ratings and scores on the AMMA. We first examined the effect of mating primes on men. Our first hypothesis stated that men primed to think about short-term or long term mating would have higher musical ratings (H1) than men in the neutral condition. Planned contrasts revealed that men primed for short-term or long-term mating did not score

higher than men in the neutral condition the composite musical ratings, or on any of the AMMA scales.

We then examined the effects of mating primes on women. This group of analyses predicted that women primed to think about long term mating would have higher ratings on the musical production task than women in the short-term or neutral condition on composite musical ratings (H2). No differences were expected on scores on the AMMA. Contrasts revealed that women who were primed to think about long-term mating had higher composite musical ratings than women in the neutral condition, $t(44) = -2.02, p = .049, d = .73$ and women in the short-term mating condition, $t(44) = 2.730, p = .009, d = .96$. Differences were not found between women in the neutral, short-term, or long-term mating groups for scores on the AMMA.

Our next hypothesis compared men and women's performance after reading a short-term mating prime. We predicted that within the short-term condition men would have higher ratings than women on the musical production task (H3). As predicted, men had higher ratings than women in the short-term mating condition, $t(29) = 2.231, p = .034, d = .83$. We also found that men had higher ratings than women in the neutral condition $t(29) = 2.058, p = .049, d = .75$. As expected no differences were found on the AMMA.

Influence of Variables Known to Affect Mating

We also explored the effects of variables known to be associated with mating and mate choice. To consider the effect of raters' sex, musical rating averages were calculated using male raters ($n = 23$), and then female raters ($n = 59$). All musical rating variables

were normally distributed. The male musical rating and female musical ratings were used as dependent variables in a MANOVA examining the effects of sex (of the music producer) and mating prime group on ratings.

The overall multivariate test (Wilks' Lambda) was not significant $F(4, 170) = 2.0, p = .097, \eta_p^2 = .045$. Within the MANOVA, omnibus univariate tests revealed no significant main effect for sex (of the performers) when rated by only males $F(1, 86) = 3.869, p = .052, \eta_p^2 = .043$ or when rated by only females, $F(1, 86) = 3.613, p = .061, \eta_p^2 = .040$. Interactions were found when rated by only males $F(2, 86) = 3.458, p = .036, \eta_p^2 = .074$ but not when rated by only females $F(2, 86) = 2.080, p = .131, \eta_p^2 = .046$. In order to unpack this significant interaction when males were rating, post hoc pairwise comparisons were performed indicating that when men rated musical pieces, males and females significantly differed in short-term but not the neutral or long-term mating prime groups. Specifically, only after reading a short-term prime men rated male performances significantly better than female performances (Males = 3.702 > Females = 2.889, $p = .015$).

Ovulation is known to affect women's taste in mates and behavior toward potential mates. Therefore, we investigated whether mating primes differentially affected females who had a high chance of ovulation on the day of testing. The average day of ovulation is on day 14.6 of the cycle. There is great variation both among women and between cycles. A 95% confidence interval includes women between day 12 and 20 of their cycle (Geirsson, 1991). Only 14 women (3 in the neutral condition, 3 in the short term condition, and 8 in the long-term condition) met this criterion. We carried out MANOVAs using ovulating women and all men to examine differences between mating prime group (neutral, short-

term, long-term) and sex (male, female) on the seven musical ratings and the four measures of musical aptitude. The observed power for the seven musical ratings ranged from .114 to .440. This suggests that even if there was a real difference in the populations for this measure, we would have less than a 50% chance of detecting the effect with a sample size of this size. The observed power for musical aptitude ranged from .050 to .493, suggesting a similar problem. Therefore we were unable to investigate if ovulation impacted musical production or aptitude by group. Thus, a *t*-test for independent means was conducted to investigate if ovulating women performed differently than non-ovulating women on musical production ratings or musical aptitude. Women who were ovulating did not perform differently than non-ovulating women on the production task or measures of musical aptitude ($p > .05$).

Each of the other related variables (i.e., mood, caffeine intake, mating situation, and number of ideal mates) were entered as covariates in our multivariate analyses examining overall group differences to determine the effect (if any) on musical production and/or aptitude. We examined the effects of mating prime group and sex on the composite musical rating and scores on the AMMA using the BDI-II (Beck Depression Inventory), BAI (Beck Anxiety Inventory), number of caffeinated beverages on day of testing, number of ideal mates, short-term partner seeking (0% to 100%), and long-term partner seeking (0% to 100%). A MANOVA was conducted using group membership (neutral, short-term, long-term) and sex (male female) as fixed variables. Our dependent variables were the composite musical rating and the three measures of the AMMA (tonal, rhythm, and total)

and all covariates were entered into this MANOVA.⁷ The overall multivariate tests (Wilks' Lambdas) were significant for the degree to which participants were seeking a short-term mate, $F(4, 69) = 2.610, p = .043, \eta^2 = .131$. Within the MANOVA, omnibus univariate tests were significant for the rhythm scores on the AMMA when variation in the number of ideal mates was accounted for, $F(1, 72) = 6.422, p = .013, \eta_p^2 = .082$. A significant difference by group was also found for rhythm scores on the AMMA when variation in amount seeking a short-term mate was accounted for, $F(1, 72) = 5.725, p = .019, \eta_p^2 = .074$. Finally, significant differences were found for the musical composite scores when variation in amount seeking a short-term mate was accounted for, $F(1, 72) = 4.328, p = .041, \eta_p^2 = .057$.

Underlying constructs of musical production

Our next analyses related to the underlying constructs of musical production. We aimed to answer the following question: Is mental flexibility (operationalized as IQ, divergent thinking, and executive functioning) related to the production of a novel musical piece? To address this hypothesis (H5), we carried out two linear regression analyses. The first analysis used musical composite ratings as the criterion variable and the second analysis used the total AMMA scores as the criterion variable. Both analyses used IQ (measured by the total raw scores on the Raven's progressive matrices) and executive functioning (measured by the combined scaled score on Design Fluency) as predictor variables. Although the divergent thinking (ATTA) was included in the initial hypothesis, this variable was non-normal and could not be rectified by a log, square root, sine, or

⁷ Five participants did not indicate their number of ideal mates. One participant failed to indicate the extent to which he was seeking a short-term or long-term mate. Two participants did answer all questions on the BDI. Results are based on 84 participants.

arcsine transformation and was therefore not included. Results of the regression for musical composite ratings indicated that IQ and design fluency only accounted for a small amount of overall variance ($R^2=.013$) in the musical composite ratings of the musical pieces. Neither predictor variable explained a significant amount of variability. The second regression indicated that a minimal amount of variance for total AMMA score was accounted for ($R^2=.042$) by IQ and design fluency. Again, neither predictor variable explained a significant amount of variance.

Our final analysis examined whether mating primes and sex affected performance on our other measures (H6). MANOVA was performed on the three design fluency conditions (df 1, df 2, and df 3), and the Raven's progressive matrices raw score. Group membership was used as the fixed factor (neutral men, neutral women, short-term men, short-term women, long-term men and long term women). We found no significant differences between groups. Due to the high degree of skew and kurtosis, a Kruskal-Wallis test was performed to examine group differences on the ATTA (raw score on fluency and originality). Results were not significant: Fluency, $X^2(5, N=92) = 4.693, p >.05$; Originality, $X^2(5, N=92) = 5.460, p >.05$.

Discussion

Overview

The primary goal of the present research was to determine whether music is a sexually selected trait by investigating if men and women differentially *display* musical ability as a function of mating primes. Differences between the sexes on measures of musical performance but not musical aptitude would support the idea that music is a way to showcase underlying fitness (Darwin, 1871; Miller, 2000a, 2000b). A secondary goal was to determine if musical production is impacted by variables known to affect mating such as mood, ovulation status, current mating situation, caffeine intake, or the sex of the raters. A final goal was to understand better the cognitive mechanisms that underlie musical production—in particular, higher-order cognitive processes that tap mental flexibility measured through tasks of divergent thinking, executive functioning, and general intelligence. This final goal builds upon previous research suggesting that the specific fitness that music indicates is “fluid g” (Miller, 2000a, 2000b).

To investigate these goals, a two-part study was conducted. In the first part, 92 undergraduates read a neutral, short-term mating, or long-term mating vignette created by Griscivious, Cialdini, and Kenrick (2006). Mating prime vignettes are included in Appendix E. The short term mating prime encouraged participants to think of the last day of a vacation on an island. On this last day, they meet a new romantic interest, and the story ends with the two lovers kissing passionately on a moonlit beach. In the long-term prime scenario, participants imagined themselves meeting someone on the university’s campus and spending a wonderful afternoon and romantic evening with this person, including a

candlelight dinner and a sweet kiss goodnight. The long-term scenario included intended commitment: (1) the couple has been dating a while; (2) trustworthiness (the participant has met and likes the target's friends); and (3) the target was "good relationship material" (the target has met the participant's friends, and they approve). The long-term scenario belabors the idea that this person may be a good long-term partner and ends with the reader anticipating an "official" first date. Finally, in the neutral scenario, two same sex friends go to a much-anticipated concert. All three scenarios are approximately 850 words in length and have been shown to successfully prime participants in a study on creativity (Griscivious, Cialdini, & Kenrick, 2006).

After reading the vignettes participants indicated the extent to which they experienced sexual and romantic arousal on a 7-point scale (1-not at all to 7-very much). Then, participants completed tasks measuring our primary outcome measures. Next, to measure musical performance participants created a novel piece of music on a xylophone. Then participants completed tests of mental flexibility including executive functioning (D-KEFS Design Fluency), IQ (Raven's Progressive Matrices), and musical aptitude (AMMA).

In the second part of the study, 82 undergraduates listened to the musical pieces created in part one and rated them on seven dichotomous variables on a scale from 1 to 8: Low Quality/High quality, Unappealing/Appealing, Expressionless/Expressive, Unimaginative/Imaginative, Without Rhythm/Rhythmic, No melody/Melodic.

Primary hypothesis: Sex and priming effects on musical production and aptitude.

Our primary hypotheses predicted statistically significant differences in musical ratings between the sexes and as a function of mating prime. We first confirmed that our mating primes had the desired effect. Men and women who read the short-term and long-term mating primes reported feeling more sexually and romantically aroused than men and women in the neutral group. In addition, those who read the short-term prime were significantly more sexually aroused than those who read the neutral or long-term primes. No significant difference was found for romantic arousal between the short-term and long-term conditions. Importantly men and women did not differ across priming conditions. As expected, participants reported significantly more arousal after reading a short-term or long-term mating prime as compared to a neutral prime.

To understand the contribution of arousal to musical production we examined whether musical performance differed as a function of high or low arousal broken up by sex. We found that there were no differences in musical performance based on high or low self reported sexual or romantic arousal for men or women. We also demonstrated that the visibly pregnant experimenter did not affect musical performance, a potential confound.

As predicted, our primary analysis revealed sex differences in musical production. Overall sex differences were not found for musical aptitude. Using musical composite ratings across all raters (n=82) as the dependent variable, the omnibus univariate tests revealed that music created by men was rated as better than music created by women.

Concerning our a priori hypotheses, planned contrasts revealed no differences among the men by vignette group for musical production or musical aptitude (H1). But as predicted, significant differences were found for women by vignette group for musical

production, but not for musical aptitude (H2). Lastly, we found that men and women's ratings significantly differed for musical production in the neutral and short-term mating prime groups (H3). Men and women performed similarly for musical aptitude.

In accordance with sexual selection theory, where parental investment contingencies predict greater male displays of sexually selected traits, we find that as a group, raters rated the compositions by men higher than compositions by women. This was true even though the raters were unaware of the composers' sex. None of our participants had any identified talent or training in music, meaning that most would not choose music as a way to demonstrate fitness. Instead, a different skill (e.g., athletic prowess) that had been practiced would likely demonstrate better fitness. Using only participants with no musical training was a conservative approach. It suggests that humans have some innate understanding of music and that aspects judged as good (such as complexity or imaginative) can be expressed through music with no formal training. This supports the idea that music is or has recently been sexually selected for. If non-musicians can create music judged as expressive, imaginative, complex, and rhythmic then music is likely not a skill that can only be trained (as Pinker would argue).

We also demonstrated that musical performance was not the product of high or low arousal, which suggests that the phenomenon we are observing is not driven by differences in arousal, but likely by differential mating strategies. It has been demonstrated that males and females behave differently as a result of arousal (Buss, 2009), and our finding supports this claim.

There were no sex or group differences on the AMMA, a measure of musical aptitude. This finding confirms that men and women in our study did not differ in musical ability. It also supports the idea that differences in musical production were not related to differences in aptitude.

Our findings revealed that men performed uniformly across all three mating conditions. Differences were not found between men in the neutral and men in the short-term or long-term prime conditions. This finding may be caused by an unintentional prime imbedded in the directions of the musical production task. Participants were told that their pieces would be “rated by members of the opposite sex.” This statement alone may have been enough to put male participants in a mating mindset. According to human mating theory there are generally more men “on the market” at any given time than women, causing men to fight more fiercely for mates. As a result men are quicker to show off abilities and act on any perceived female mating signals. For example, men display their physical strength 50% more often than women (Buss, 2003). Men also misperceive friendly behavior from women as interest in sexual relations (Abbey, 1982). Additionally Griscivious, Cialdini, and Kenrick (2006) found that men showed a boost in creativity after seeing an attractive female photo, reading about a short-term mating situation, reading about a long-term mating situation, and reading about a long-term mating situation that included the qualities of commitment and trustworthiness. Females only exhibited a boost in creativity after reading a long-term mating prime that included the qualities of commitment and trustworthiness.

Another possible explanation for the uniform performance by men might be that they are *always* displaying abilities. Having more viable men on the market might cause men to always be showing off their abilities. Experimentation would need to confirm these possibilities.

Women, on the other hand, displayed group differences in the expected direction. Musical pieces created by women in the long-term mating prime were rated as better than compositions created by women in the neutral group or short-term group. A study on creativity and mating primes found similar results (Griskevicius, Cialdini, & Kenrick, 2006). Griskevicius used the same mating vignettes as those used in the current study. However, he used a within subjects design and had participants take half of the remote associates test (RAT; Mednick, 1962), a measure of creativity, before reading one of the mating primes and half after reading one of the mating primes. Griskevicius and colleagues found that women who read the long-term prime performed better on a measure of creativity than women who read the neutral or short term prime. Griskevicius concluded that this demonstrated that women show an increase in creativity only when they are primed with a long-term mate who is high-quality relationship material.

Unlike most mammals, where the burden of parental investment is borne by the females and the males do the displaying and females do the choosing, human mating is more complicated. Humans' parental investment is very different in short-term verses long-term mating scenarios (Buss & Schmitt, 1993; Trivers, Houck, & Drickamer, 1996). In a short-term scenario the female will bare much responsibility for the off spring rearing, whereas in a long-term relationship it is likely that both parents will invest. These

differential parental investments directly affect mating behavior. It has been shown that in short-term mating situations (one night stand) because the parental investment is especially high for women, females desire and seek fewer short-term mates than males. Further, in the event that a woman does engage in a short-term mating situation it is usually because of an opportunity for access to exceptional genes (Gangestad & Simpson, 2000). In long-term compared to short-term scenarios parental investment increases for men (although still highest for women) and therefore both sexes should be exhibiting their “good” genes. In species with high male parental investment, both parents invest considerably in a long-term mate and both sexes tend to be choosy about the characteristics of the long-term mate (Geary, 2000). Our finding that ratings for women’s musical pieces created after reading a long-term mating prime were better than for musical pieces created after reading a neutral or short-term mating prime is consistent with evolutionary mating theory and supports two important ideas. First, women showcase musical fitness in long-term mating situations indicating that in long-term situations both men and women choose mates. Second, women display musical ability in the same manner as they display other sexually selected traits such as creativity (Griskevicius, Cialdini, & Kenrick, 2006) and humor (Kaufman, Kozbelt, Bromley, & Miller, 2008).

Overall, like findings by Griskevicius, Cialdini, and Kenrick (2006), thinking about long term mating that included the traits of commitment and trustworthiness resulted in high ratings of musicality for both sexes, *but* when participants were primed to think about short-term mating only the men showed received high musicality ratings. This finding supports the idea that music is sexual selected for. First, displays of musicality mirrored

the differential sexual strategies outlined by mating theory (Buss, 2009). Men and women typically differ in how long and how well they need to know someone before they consent to sexual intercourse. Although there are many exceptions and individual differences, men generally have lower thresholds for seeking sex. Men often express the desire and willingness to have sex with an attractive stranger, whereas most women refuse anonymous encounters and prefer some degree of commitment. The women in our study only displayed musicality when they were thinking about a mate that indicated commitment and trustworthiness. Second, simply finding variability in musicality is an indication that music might be sexually selected for. Feist (2004) mentioned that naturally selected traits attenuate over time, put plainly, everyone has naturally selected traits. Sexually selected traits, on the other hand, should show variability because they are reflecting some underlying fitness of which individuals possess different amounts. Humans, who fail to inherit a naturally selected trait, will be at a survival disadvantage and will eventually die out. In London there are moths who in the 1800s were all white; occasionally a mutation would cause a moth to be gray, and the gray moth was easily spotted by prey against the white buildings in London and quickly eaten. The industrial revolution caused the buildings in London to be covered by a layer of soot. Now the gray moth had a survival advantage. Being gray against the soot-covered buildings was a naturally selected trait. All the moths without this trait (the white moths) were quickly eaten. Conversely, sexually selected traits will always create variability within a population. Our study found variability even with averaged ratings and a restricted performance range. Each piece was rated by 82 people, collapsing much of the variability among raters. Pieces were created using an instrument with a generally unfamiliar and

restricted range. Unlike real instruments, the xylophone only has five notes and the notes were not on an equal interval scale. Taken together our overall sex difference suggests that music may be sexually selected for in modern day humans.

A principle component analysis confirmed that one factor accounted for most of the variance, suggesting that the ratings were similar among the seven aspects of music. In addition to the main analysis on the musical composite score, results of analyses for the individual dichotomous variables (presented in Appendix F) indicated that ratings significantly differed between men and women for Expressiveness, Imagination, Complexity, and Rhythm, but not for Quality, Appealingness and Melody. When these same analyses were run excluding eight participants with mood disturbances, differences were found for Quality, Expressiveness, Imagination, Complexity, Rhythm, and Melody. Taken together, these findings suggest that no particular aspect of music stands out. That said, the finding that sex differences were only found for Quality and Melody when participants with mood disturbances were excluded is interesting. One interpretation is that mood disorders get in the way of the prosody of the piece. People suffering from mood disorders often display blunted affect. This might also extend to music.

Of note, our analyses did not reveal any significant interactions between sex and mating type for musical composite ratings when we included all 82 ratings. This finding is likely an effect of our small sample size. The effect size for our sex effects were medium, ranging from $\eta_p^2 = .25$ to $\eta_p^2 = .58$. Power for an experiment with a medium effect size for 3 groups of 15 at the .05 significance level is .29. This means that there was only a 30% chance of finding significant differences if they truly differed in the population. When

musical ratings were considered separately, all seven of the ratings differed between groups and among sex in the same direction. If the experiment was repeated with a larger number of participants we might also see significant interactions. Another explanation for our lack of interactions is that we lose variability when collapsing the ratings of 82 raters.

Influence of Variables Known to Affect Mating

We considered the effects of variables known to be associated with mating and mate choice through an exploratory hypothesis (H4). This hypothesis investigated whether the results for the first five study hypotheses changed as a result of the relevant covariates of sex of the raters, ovulation, caffeine intake, current mating situation, number of ideal mates, and mood.

Sex of the raters. We found no effect of sex, such that musical pieces composed by men and women were rated similarly by male and female raters. An interaction was found when men did the rating, but not when females did the rating. We found that when men rated musical pieces, males and females significantly differed in short-term but not the neutral or long-term mating prime groups. Specifically, only after reading a short-term prime men rated male performances significantly better than female performances (Males = 3.702 > Females = 2.889, $p = .015$).

There are a few ways to conceptualize how sex of the rater could affect ratings. First, one might expect women to be more discerning, because there are more available males on the market at any given time and females are often *choosing* while the men are competing. Alternatively, men and women might be equally discerning of the traits of

potential mates; women because they are doing the choosing and men because they have to be adept at “sizing up” the competition.

A third possibility is that men and women are equally discerning because they are both invested in choosing a long-term mate. Sexual selection comes in two forms. In one form, members of the same sex compete with one another for access to members of the opposite sex, often called *intrasexual selection*. In the other type of sexual selection, members of one sex choose a mate based on their preferences for particular qualities, *intersexual selection* (Darwin, 1871). Compared to the results using all 82 raters, the subgroup of only male raters was more discerning. Using the 23 males revealed interactions that were not found using only women or when we used all 83 raters. Comparisons indicated that the effect of sex varied according to the effect of mating prime when men rated musical pieces, such that males performed significantly better than females in short-term but not in neutral or long-term mating prime conditions.

Although this finding supports the idea that men and women display musical ability as a function of mating prime, it could be an artifact of statistical power. Significance may have been found when considering only male raters simply because there were fewer of them. The variability between ratings was lost using averages, so it might be that by using a smaller subset ($n = 23$) some variability was regained.

Ovulation. Ovulation is known to affect women’s taste in mates and behavior toward potential mates. The average day of ovulation is day 14.6 of the cycle but there is great variation both among women and between cycles. A 95% confidence interval includes women between the 12 and 20 days of their cycle (Geirsson, 1991), and only 14

women in the current study met this criterion. We carried out MANOVAs using ovulating women and all men to examine differences between mating prime group (neutral, short-term, long-term) and sex (male, female) on the seven musical ratings and four measures of musical aptitude. The observed power, however for the seven musical ratings and for the musical aptitude was quite low. A *t*-test for independent means revealed that ovulating women did not perform differently than non-ovulating women on the musical production ratings or musical aptitude.

Mood, Caffeine, Mating situation, and Number of ideal mates. Each of the other related variables (i.e., mood, caffeine intake, mating situation, and number of ideal mates) were entered as covariates in our multivariate analyses examining overall group differences to determine the impact (if any) on musical production and/or aptitude.

We found that rhythm scores on the AMMA differed significantly by group when variation in the number of ideal mates is accounted for and when variation in amount seeking a short-term mate is accounted for. We also found group differences for the musical composite scores when variation in amount seeking a short-term mate is accounted for.

We can take these findings to suggest that the rhythmic section of the AMMA and group differences on the musical performance measures share a significant amount of variance with amount seeking a short-term mate. The rhythmic section of the AMMA also shares a significant amount of variance with number of ideal partners.

Underlying constructs of musical production.

Another aim was to investigate whether mental flexibility is related to the production of a novel musical piece. To address this hypothesis (H5), we carried out two linear regressions using IQ (measured by the total raw scores on the Raven's progressive matrices) and executive functioning (measured by the combined scaled score on Design Fluency) as predictor variables. The first analysis used musical ratings (as measured by complexity ratings) as the criterion variable and the second analysis used the total AMMA scores as the criterion variable. Results indicated that a very small amount of the variance was accounted for by the overall model. Further, no correlations existed between the Raven's progressive matrices (one of the purest measures of fluid intelligence (Horn, 1994)) or musical aptitude and musical performance ratings. Therefore, we concluded that in this study mental flexibility and IQ do not seem to be associated with the production of a novel musical piece. This finding is inconsistent with Miller's (2000a, 2000b) hypothesis that music is a domain through which fluid 'g' is being showcased. An explanation for this finding might be that musicality showcases *emotional intelligence* and not fluid 'g'.

It may be that music originated as a way to facilitate bonds between parents and children, and was later co-opted as indicator of emotional intelligence. As established above (see pg. 9), increased infant survival enabled by stronger parent child bonds through singing has been characterized as an indirect benefit and possible origin of music (Dissanayake, 2000). Music may have conferred this benefit by modulating emotional arousal and thereby promoting infant survival and/or development (Fitch, 2006; Mithen, 2005). Research on infants today demonstrates that lullabies mediate arousal of infants, draw attention to important stimuli, ease infants when they are upset, induce sleep, and

precipitate changes in saliva cortisol levels (Lecanuet, 1996; Trehub & Hannon, 2006; Woodward, 1992). Additional research indicates an emotional basis to music in adults. While listening to classical music humans activate the mesolimbic system (Menon & Levintin, 2005), a loop of dopamenergic pathways including the ventral tegmental area, nucleus accumbens and the amygdala. Addictive drugs, sex, hunger and thirst also activate this area. The idea is that dopamine release in this area is a potent reward that aids memory and learning, particularly for things that are essential for survival. Therefore it could be that music originated as a way to bond with babies, but that the emotional content was later co-opted as an honest signal of emotional intelligence in a mate.

Emotional intelligence is defined as a cognitive ability, which is both related to, and partially separate from, standard intelligence tests (Petrides & Furnham, 2003). Schulte, Ree, and Carretta (2004), investigated the relatedness of EI, general cognitive ability ('g'), and personality. They found that a model including three measures of 'g', the personality dimension Agreeableness, and sex accounted for 62% of the variance in EI. Conversely, in a recent paper (Austin, 2010) emotional intelligence was shown to be distinct from general intelligence and personality. In modern day humans emotional intelligence has been linked to many important abilities such as job performance and leadership (Barbuto & Burbach, 2006; Carmeli & Josman, 2006), academic success (Majeski, 2004), social competence (Rieffe & Bakker, 2007) and quality of relationships (Barbuto & Burbach, 2006; Carmeli & Josman, 2006). Therefore although the uniqueness of EI as a predictor of human behavior remains ambiguous, its inclusion in future studies is warranted.

Research on communication of emotions between a performer and an audience supports the idea that music successfully communicates emotion (Juslin & Laukka, 2003). In these studies musical performers were asked to communicate different emotions to listeners. The intentions of the performers and the responses of the listeners were analyzed in detail. Four basic emotions were consistently communicated to the listeners: happiness, sadness, anger, and fear (Juslin & Laukka, 2003). Interestingly musical training had little effect on listeners' ability to recognize the emotional information in music. Therefore, some assert that the ability to recognize emotional information in music may be part of a more general ability to understand emotions (Mayer, 1999). To that end Resnicow, Salovey, & Repp (2004) found a positive relationship between identifying emotion in music and emotional intelligence ($r = .54$), which suggests that listening to music may draw on the same sensibilities as everyday emotional intelligence. This supports the idea that music could showcase emotional intelligence.

We found no meaningful correlations between musical aptitude (on the AMMA) and IQ. As has been found in other studies, musical aptitude and IQ may independently contribute to musical performance. Using a hierarchical multiple regression, Ruthsatz and colleagues (2008) showed that IQ, AMMA, and practice time (hours of deliberate practice) independently accounted for a significant amount of variance in musical performance (Ruthsatz, Detterman, Griscom, & Cirullo, 2008). Levitin and Cook's (1996) discussion on music and memory delineated a possible neural mechanism for this finding. Humans have specialized memory for music (Miller, 2000b). Musical memory may not overlap with the memory capacities tested through more general intelligence tests. It is well established

that the hippocampus and prefrontal cortex are used for storing and retrieving particular forms of memories. However it is 'likely that a number of processes related to memory are located throughout the brain,, and actually encompass somewhat independent processes' (Levitin & Cook, 1996, pg. 295). It is possible that we did not observe an association between the AMMA and IQ because the type of memory store for music is different than the type of memory used for the problem-solving task required by the Raven's.

Our final analysis examined whether mating primes and sex affected performance on measures of mental flexibility (H6). MANOVA was performed on the three design fluency conditions (df 1, df 2, and df 3) and the Raven's progressive matrices raw score. We found no significant differences between the groups.

General Summary

Overall, our findings support the idea that music is sexually selected for. These findings are consistent with theories of sexual selection and parental investment (Darwin, 1871; Trivers, Houck & Drickamer, 1996). Males had better rated musical pieces than females. Males and not females had better rated musical displays when primed to think about short-term mating. Similar examples can be found in nature when there is a selectively high female investment. For example, the male African village weaverbird contributes only sperm to parenting and builds an elaborate nest of grass and twigs. If the female deems the nest worthy, she will mate with the male and use the nest for rearing. Female weaverbirds carry out all of the chick raising so they are particularly interested in

the nest as an indicator of male building ability (*genes*) and as a place to protect chicks (*nuptial gift*). Weaverbirds' preferences have evolved because they bestowed a reproductive advantage over other weaverbirds who did not inspect nests, but mated with whoever came along. Music might be a human equivalent of the weaverbird nest in short-term situations. Women in evolutionary history may have chosen to mate with men who displayed superior musicality because it was indicative of some genetic or nuptial advantage.

Our findings also fit nicely with parental theory for long-term situations. When both men and women invest significantly in offspring, both sexes are choosier when selecting a mate and both sexes display qualities in courtship. In nature, gibbons serve as a good example. Male and female gibbons invest substantially in the rearing of spawn. They also both participate in courtship displays. During courtship male and female gibbons sing to each other in a sort of duet, referred to as song splitting (Geissmann, 1984). When the mating pair begins signing its duet, the male sings the notes that are in his range and the female sings the notes that are in her range, and they simultaneously sing notes in overlapping ranges (Wickler & Seibt, 1982). If one member of the pair is unsatisfied with the performance, it stops singing and looks elsewhere. This study suggests that in long term situations music may act like a gibbon song. The males and the females display music in the hopes of impressing and being chosen by the other. In sum, music ability fulfills many of the criteria of a sexually selected adaptation: it develops spontaneously and reliably in humans, it elicits strong emotions, it is ubiquitous, it uses specialized memory

capacities, and it is displayed differentially by men and women contingent upon parental investment.

Limitations

An important study limitation was the nature of the directions for the musical production task. Informing participants that their musical pieces would later be rated by members of the opposite sex may have had an unintentional priming effect. It is possible that this effect was confined to men in the neutral condition--because men in the short-term and long-term conditions should have already been thinking about mating, and previous research has indicated that women need assurance that a potential mate is trustworthy and committed before displaying traits.

Certain testing procedures may have interfered with the study outcomes. Due to space restrictions, participants completed testing in three different rooms (see Appendix C for details). After reading the prime, participants completed the arousal questionnaire and musical production task and were then moved to a new room. The change of setting may have affected the prime because of what participants encountered along the way. Length of testing also may have affected the usefulness of the prime. Research suggests that priming in this manner is salient for about 15 minutes, but many of our participants exceeded this limit. The sex and age of the experimenter may have also influenced the results. Finally, many subjects were tested by a pregnant woman. The experimenters could have unintentionally provided mating cues that affected task performance. For example, a pregnant woman may cue long-term mating strategies and therefore naturally prime males

for long-term mating. Such considerations should be taken into account when designing follow-up work.

In an effort to understand how ovulation affects courtship displays, we included information on ovulation for regularly cycling women. Any woman between her 12th and 20th day was included in the ovulating group. This method is crude, and probably includes many women who are not in fact ovulating. We also only collected information on the ovulation of women who produced music. Research indicates that ovulating women prefer different male traits, not that they differentially display traits. This oversight should be corrected in a follow-up study that measures ovulation using basal body temperature and includes women who both *produce* and *rate* the musical pieces.

Future Directions

This study is the first to empirically investigate if music is a way to showcase fitness. Future studies will aim to couch these findings in broader and more meaningful contexts by: (1) understanding the contribution of other sexual selection pressures such as cultural selection to human music; (2) considering the specific aspects of music that are being selected; (3) investigating what (if any) emotions are being activated or communicated during courtship; and (4) examining the motivational factors involved with displays of music.

(1) Evolution can be driven by several mechanisms such as natural, artificial, and sexual selection pressures. The present research focused on the latter pressure as a tool for understanding human musicality. However, one type of selection pressure that merits

discussion is cultural evolution, specifically via the ratchet effect. Tomasello (2000) argued convincingly that cultural evolution is driven by social forces that enable agents to share experiences. For example, according to this view, language learning is largely a social product involving joint attentional scenes, during which agents share social experiences to identify external referents. The ratchet effect, in particular, takes aim at how both human and non-human primates establish and promulgate adaptive behaviors. For example, chimpanzees are adept social learners. Suppose a chimp is hungrily (and clumsily) grabbing at a termite mound in an attempt to catch and eat termites. Fortuitously, it then pushes a stick into the mound and the termites cover the stick. This chimp has just invented the world's first termite lollipop. Nearby chimps, after observing this innovation, mimic its behavior and enjoy its creative insights instantaneously. This example typifies the ratchet effect, which expresses how the innovations of individuals are immediately saved and transferred throughout a cultural populace, whereas other species work "on their own", so to speak, and re-create innovations rather than learning from and expanding upon others'. It seems that human cognition is designed to mimic others and build upon their innovations, which helps generate a rapid spread of information. In this sense, information ratchets up in a manner that motivates both individual and cultural evolution.

Music is a likely candidate for the ratchet effect. When a student learns to play the guitar, he or she does not start by carving out a piece of wood, but rather benefits from the 30,000 years of human instrument ingenuity, and buys a Yamaha at the nearest shop. Musical theory, technique, and style have also benefited from what Tomasello refers to as

the ratchet effect. Future investigation of the interaction of cultural and sexual selection pressures should be pursued.

(2) Future studies should consider what musical aspects are being appreciated by raters. Our study included seven internal musical aspects (Quality, Appealingness, Expressiveness, Complexity, Rhythm and Melody). According to Schafer and Sedlmeier (2010), there are also equally important music-external aspects to musical preferences. In this study participants rated how much they liked six differently styled pieces of music and indicated how much they agreed with a list of statements concerning cognitive (communication and self reflection), emotional, and cultural function of music, psychological arousal, and familiarity with types of music. Regression analyses showed that a significant amount of the variance was account for by each parameter and that cognitive functions of music and psychological arousal were the most important in determining musical preferences. Future studies should consider music-internal and music-external aspects of musical preferences.

(3) Research has shown that happiness, anger, sadness and fear (Juslin & Laukka, 2003) can adeptly be communicated to an audience through music. Kaufman et al. (2009) have suggested that emotional intelligence may play an important part in sexually selected traits. Their study found that art forms of creativity are rated as sexier when compared to scientific forms of creativity. Understanding what emotions are being communicated, perceived, or understood by the mating process would contribute to our understanding of whether and how emotional intelligence is related to musical displays.

(4) When women produced music after reading long-term primes, their products were rated as better than women in the short-term or neutral conditions. A future study should investigate whether the motivation causing this phenomenon is implicit or explicit. Griskevicius, Cialdini, and Kenrick's (2006) study on creativity examined motivation. After completing the first 20 items of the Remote Access Test, participants were provided with a monetary reward. The researchers found that money was not enough to show a boost in performance, concluding that the motivation was implicit. Musical production might also be implicitly motivated.

In summary, the present study sought to determine if music is a sexually selected trait by investigating whether men and women differentially *display* musical ability as a function of mating primes. Differences between the sexes on measures of musical performance but not musical aptitude supported the notion that music is a way to showcase underlying fitness (Darwin, 1871; Miller, 2000a, 2000b). The present research also determined that musical production was not affected by variables known to affect mating such as mood, ovulation status, current mating situation, caffeine intake, or the sex of the raters. This study did find that musical production was affected by current mating situations and the sex of the rater. Finally the present research found no meaningful association between mental flexibility (as measured on tasks of divergent thinking, executive functioning, and IQ) and musical production. Taken together results suggest that musicality is a very complex domain that can be understood from a multiplicity of viewpoints. An understanding of the evolutionary mechanisms involved in musicality will permit better understanding of the nature of humans, and hopefully someday the mind.

Table 1

Participant demographics by group for part I of the study

Characteristic	Participant Group						<i>p</i>
	Neutral		Short-term		Long-term		
	n = 30		n = 31		n = 31		
	<i>M</i>	<i>S.D.</i>	<i>M</i>	<i>S.D.</i>	<i>M</i>	<i>S.D.</i>	
Age, yrs.	22.67	2.67	21.77	2.75	21.58	2.55	<i>n.s.</i>
Education, yrs. ¹	15.67	1.59	15.25	1.04	14.97	0.96	<i>n.s.</i>
GPA ²	3.20	0.42	3.36	0.45	3.26	0.60	<i>n.s.</i>
Sex (M, F)	15, 15	---	15, 16	---	15, 16	---	<i>n.s.</i>
Seeking a short-tem mate							
(%) ³							
Males	30.00	34.46	20.38	29.33	14.67	27.67	<i>n.s.</i>
Females	4.29	16.03	3.33	12.91	16.67	27.95	<i>n.s.</i>

Seeking a long-term partner

(%)

Males	71.92	32.37	72.31	32.37	65.00	39.55	<i>n.s.</i>
Females	55.71	48.00	76.00	39.96	63.67	41.85	<i>n.s.</i>

¹Two participants in the neutral group did not indicate their level of education.

²Four participants (two in the neutral, one in the short-term and one in the long-term) did not report their GPA.

³One participant failed to indicate the extent to which she was looking for a short-term mate; results based on 91 people.

Table 2

Rater demographics for part II of the study

Characteristic	<i>M</i>	<i>S.D.</i>
Age, yrs.	20.86	4.17
Education, yrs.	13.72	0.45
GPA	3.22	0.48
Sex (M, F)	23, 59	---
Seeking a short-term mating		
(%)		
Males	30.86	27.36
Females	16.78	25.06
Seeking a long-term partner		
(%)		
Males	58.83	33.33
Females	68.02	34.89

Table 3

Descriptive statistics

Variables							
				Skewness		Kurtosis	
Musical Ratings	<i>Possible Range</i>	<i>Mean</i>	<i>S.D.</i>	<i>Skew</i>	<i>Std. Err.</i>	<i>Kurtosis</i>	<i>Std. Err.</i>
Quality	0-9	3.75	.87	.36	.25	.04	.50
Appealing	0-9	3.60	.93	.46	.25	-.15	.50
Expressive	0-9	3.8	.96	.32	.25	-.57	.50
Imaginative	0-9	3.8	.95	.27	.25	-.67	.50
Complex	0-9	3.62	.89	.18	.25	-.25	.50
Rhythmic	0-9	3.76	1.04	.40	.25	-.32	.50
Melodic	0-9	3.62	1.02	.47	.25	-.16	.50
D-KEFS Design Fluency	<i>Possible Range</i>	<i>Mean</i>	<i>S.D.</i>	<i>Skew</i>	<i>Std. Err.</i>	<i>Kurtosis</i>	<i>Std. Err.</i>
Design Fluency 1 (DF1)	0-20	10.58	3.32	.18	.25	-.26	.50
Design Fluency 2 (DF2)	0-21	11.54	3.31	.36	.25	.57	.50
Design Fluency 3 (DF3)	0-16	9.55	2.34	-.33	.21	.75	.50
Raven's Progressive Matrices	<i>Possible Range</i>	<i>Mean</i>	<i>S.D.</i>	<i>Skew</i>	<i>Std. Err.</i>	<i>Kurtosis</i>	<i>Std. Err.</i>
Raw Score	0-72	44.25	7.17	-.31	.25	-.75	.50

Percentage	0-100	27.44	20.94	.812	.25	-.05	.50
Advanced Measures of Music Audiation	<i>Possible Range</i>	<i>Mean</i>	<i>S.D.</i>	<i>Skew</i>	<i>Std. Err.</i>	<i>Kurtosis</i>	<i>Std. Err.</i>
Tonal Raw Score	0-40	24.32	3.48	.002	.25	-.49	.50
Tonal Percentage	0-100	51.50	17.69	-.14	.25	-.78	.50
Rhythm Raw Score	0-40	25.75	3.52	-.14	.25	-.50	.50
Rhythm Percentage	0-100	43.38	16.79	-.16	.25	-.65	.50
Total Score	0-80	49.93	6.26	-.040	.25	-.64	.50
Total Percentage	0-100	46.73	17.83	.14	.25	-.91	.50
Abbreviated Torrance Test for Adults	<i>Possible Range</i>	<i>Mean</i>	<i>S.D.</i>	<i>Skew</i>	<i>Std. Err.</i>	<i>Kurtosis</i>	<i>Std. Err.</i>
Torrance Fluency	0-18	6.18	2.71	.61*	.25	.34	.50
Fluency Scaled Score	11-19	11.87	1.52	.66*	.25	3.40*	.50
Torrance Originality	0-11	1.77	1.86	1.67*	.25	3.12*	.50
Originality Scaled score	11-19	11.71	1.82	1.63*	.25	3.40*	.50

*Indicates significant skew and kurtosis

Table 4

Bivariate correlations among variables of interest

Variables	1	2	3	4	5	6	7	8	9	10
1. Musical Ratings Composite	---	-.009	.059	.009	.017	-.063	.020	-.029	.326**	.025
2. Design Fluency 1		---	.644**	.410**	-.114	.086	-.022	-.063	.005	-.037
3. Design Fluency 2			---	.435**	-.114	.086	.157	.088	-.118	-.027
4. Design Fluency 3				---	.067	.142	.152	.159	-.176	-.077
5. Raven's Raw Score					---	.142	.040	.139	.026	-.004
6. AMMA Tonal						---	.602**	.906**	-.143	.144
7. AMMA Rhythm							---	.859**	-.170	.029
8. AMMA Total								---	-.175	.124
9. Seeking Short-term									---	-.218*

10. Seeking
Long-
term



Table 5

Correlations between IQ, musical ratings, and musical aptitude

Correlations		
Raven's Progressive Matrices Raw Score		
Musical Ratings	<i>r</i>	<i>p-value</i>
Quality	.037	.73
Appealing	.002	.98
Expressive	.006	.96
Imaginative	.014	.89
Complex	.030	.78
Rhythmic	.022	.83
Melodic	.011	.91
Advanced Measures of Music Audiation	<i>r</i>	<i>p-value</i>
Tonal Raw Score	.142	.18
Tonal Percentage	.152	.14
Rhythm Raw Score	.040	.70
Rhythm Percentage	.100	.34
Total Score	.139	.17
Total Percentage	.148	.16

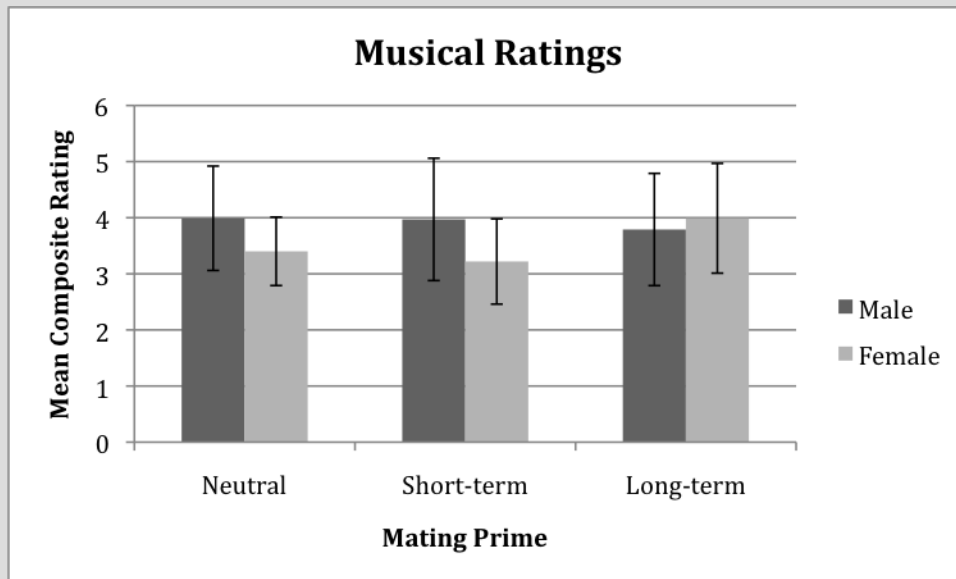


Figure 1. Musical composite ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

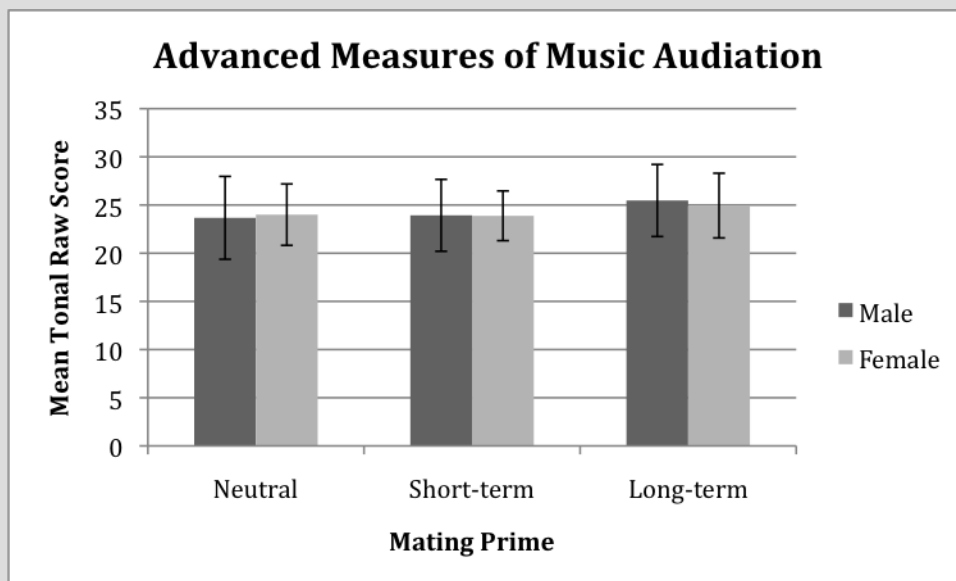


Figure 2. Men's and women's performance on the Advanced Measures of Music Audiation, Tonal subscale depending on type of mating prime.

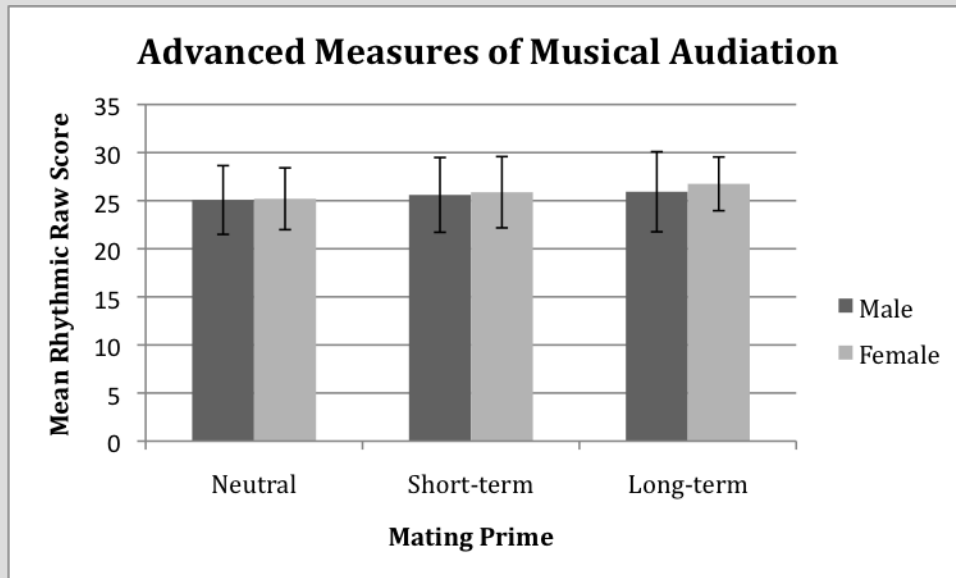


Figure 3. Men's and women's performance on the Advanced Measures of Music Audiation, Rhythmic subscale depending on type of mating prime

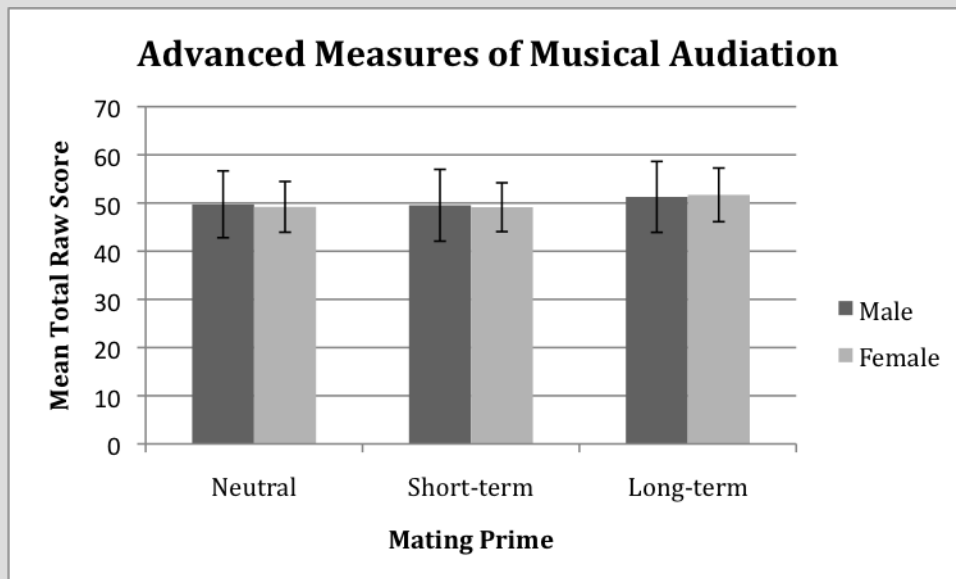


Figure 4. Men's and women's performance on the Advanced Measures of Music Audiation, Total Score depending on type of mating prime

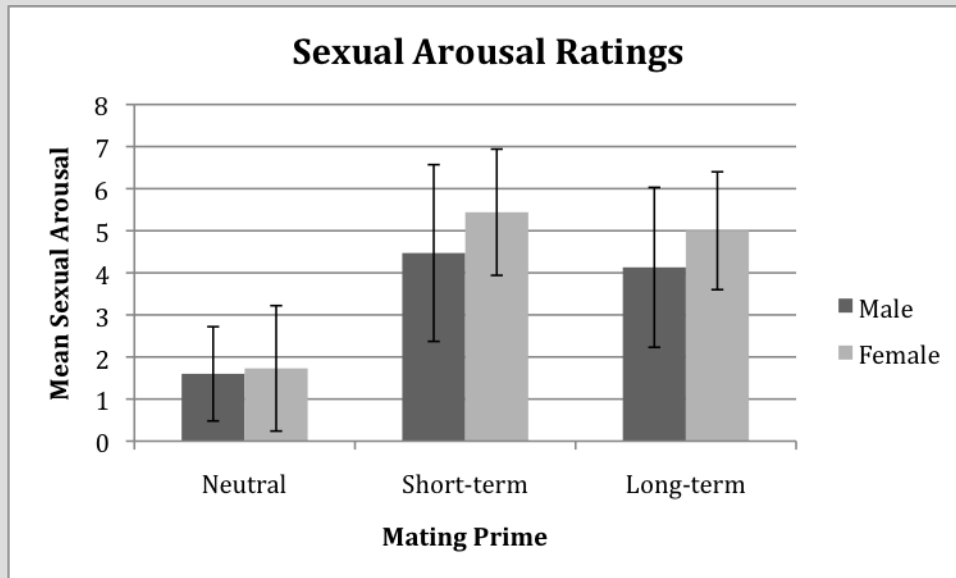


Figure 5. Men's and women's sexual arousal ratings depending on type of mating prime

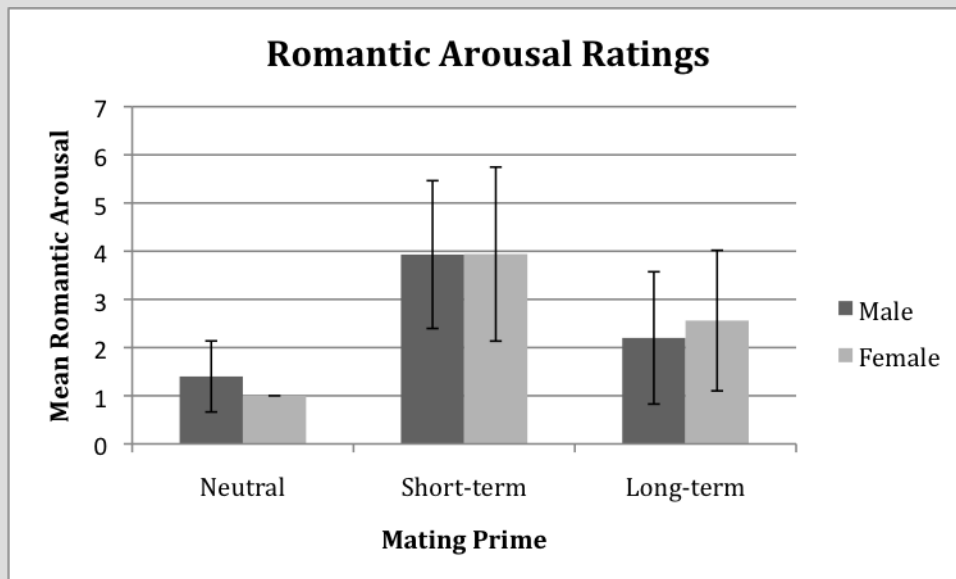


Figure 6. Men's and women's romantic arousal ratings depending on type of mating prime

Appendices

Appendix A

Musical Evaluation Survey									Track number _____
Rate the image's overall quality:									
Low quality	1	2	3	4	5	6	7	8	High quality
Unappealing	1	2	3	4	5	6	7	8	Appealing
Expressionless	1	2	3	4	5	6	7	8	Expressive
Unimaginative	1	2	3	4	5	6	7	8	Imaginative
Simple	1	2	3	4	5	6	7	8	Complex
Dull Rhythm	1	2	3	4	5	6	7	8	Interesting Rhythm
Dull Melody	1	2	3	4	5	6	7	8	Interesting Melody

Appendix B

ID# _____ DATE _____

1. Age _____

2. Sex: ___ Male ___ Female

3. Race/Ethnicity (circle)

a. African American b. Caucasian c. Hispanic/Latino

d. Asian American e. Native American f. Other _____

4. Highest Attained Level of Education: total years of education _____

Current year in college: _____

5. College Major _____

6. Overall GPA _____

7. Estimated number of caffeinated beverages you had today _____

8. Previously diagnosed neurological condition, if applicable

Specify: _____

9. Previously diagnosed psychological or psychiatric condition(s), if applicable

Specify: _____

10. Previously diagnosed learning disabilities of Attention Deficit Hyperactivity

Disorder, if applicable: Specify: _____

Sleep Behavior Last Night

1. Last night I fell asleep at _____ (time).
2. It took me about ___ minutes to fall asleep.
3. This morning I awoke at _____ (time).
4. This morning I felt well rested ___ (Yes or No)
5. I awoke about ___ times last night.
6. Last night I slept about ___ hours.

Music Section of the Creative Achievement Questionnaire (Carson, Peterson & Higgins, 2005)

Place a check mark beside sentences that apply to you. Next to sentences with an asterisk (), write the number of times this sentence applies to you.*

__0 I have no training or recognized talent in music

__1 I play one or more musical instruments proficiently

__2 I have played with a recognized orchestra or band.

__3 I have composed an original piece of music.

__4 My musical talent has been critiqued in a local publication.

__5 My composition has been professionally recorded.

__6 Recording of my composition have been sold publicly.

*__7 My compositions have been critiqued in a national publication (_____ number of times)

Mating Preferences (adapted from Buss & Schmitt, 1993)

1. How many sex partners would you ideally like over your lifetime? _____
2. How likely would you be to have sex with a desirable partner if you had known them for
 - one hour (0% chance to 100% chance) _____
 - one day (0% chance to 100% chance) _____
 - one week (0% chance to 100% chance) _____
 - one month (0% chance to 100% chance) _____
 - one year (0% chance to 100% chance) _____

3. Are you seeking a short term mate? (0 – not strongly currently seeking - 100 strongly currently seeking) _____ (0 to 100)
4. Are you seeking a long term mate? (0 – not strongly currently seeking – 100 strongly currently seeking) ____ (0 to 100)

For female participants:

When was the *first* day of your last period _____

(Please indicate the exact date if you have that information. If not, how many days prior to today?)

Do you take oral contraception? _____

If yes, what is the name of your birth control pill? _____

If yes, for how many years have you been taking the birth control pill? _____

Appendix C

Participant Number _____ Date of Evaluation _____

MUSIC BATTERY - AGES 18- 30**Order of Administration:****START IN ROOM 4307 – sound proof chamber**

- ___ Demographics
- ___ Vignette (A, B, or C)
- ___ Romantic Priming Check
- ___ Production Task

Tester (init) _____

Test Time _____

Score Time _____

MOVE TO ROOM 4107

- ___ Design (D-KEFS)
- ___ Raven's
- ___ Torrance Test
- ___ Vignette booster
- ___ AMMA (Advanced Measures of Music Audiation)

Appendix D



CONSENT TO PARTICIPATE IN RESEARCH

Brooklyn College Psychology Department

Contemporary Entailments of Music

You are being asked to participate in a **research study**. Your participation is **voluntary**. Your decision about whether or not to participate will have no effect on your coursework or academic standing. Please ask questions if there is anything you do not understand.

What is the purpose of this study?

The purpose of the study is to collect data to investigate musical ability and various aspects of cognition.

Are there any benefits from participating in this study?

While participation in this study will not benefit you directly, it will provide you with the credits you need to fulfill course requirements.

What does this study involve?

You will undergo a series of paper-and-pencil and computerized tests. We will use your results to determine the quality and relationship of the tests. The data of approximately 120 participants will be pooled using a unique ID number in place of individual names. This project requires a total of 2 hours of your time.

What will happen if you do not participate in this study?

If you do not participate in this study, your data will not be added to the database for research purposes.

What are the risks involved with being enrolled in this study?

This study poses minimal risks; it will take up 2 hours of your time and some of the tests may seem difficult or frustrating. Most people do not answer every question or finish every

test. There is also a risk of embarrassment, as we will be asking about birth control use and the first date of your last period (for females).

Other important items you should know:

Withdrawal from the study: You may choose to stop your participation at any time without penalty.

Data collection: Data collection will include demographic information such as age, sex, and date of birth as well as the results of the neuropsychological testing. For female participants information about ovulation cycles will be collected. Data will be used for the purposes described in this form. Research records will not be made available to participants or other persons or institutions.

Confidentiality: Every effort will be made to protect the names of participants in this study. Data will be stripped of names when collected and labeled with a unique ID number. Participants' names and assigned ID numbers will only be linked in a locked file cabinet in Brooklyn College, James Hall. These records will only be accessible to the researchers listed on this consent form. Your name will not be used in any publication that results from this study.

Number of participants: We expect a total of 120 participants to enroll in this study.

Who should you call with questions about this study?

Questions or concerns about this study may be directed to the researchers in charge at: (718) 951-5000 x6012.

Katherine Nutter-Upham (kenu@dartmouth.edu)

Laura Rabin, Ph.D. (lrabin@brooklyn.cuny.edu)

CONSENT

I have read the above information about **contemporary entailments of music** and have been granted an opportunity to ask questions. I agree to participate in this study and have been given a copy of this consent document for my own records.

_____	_____	_____
Participant's signature	Date	Printed Name

_____	_____	_____
Researcher/designee's signature	Date	Printed Name

Appendix E

CONTROL VIGNETTE MALES

Imagine that it's Friday afternoon during the semester. You've been working hard all week and you've been looking forward to this weekend for quite a while. You and one of your friends have two tickets for a sold-out concert that's happening tonight. Both of you have been looking forward to this show for a long time. In fact, you had to bend over backwards to get the tickets. Your friend has been talking about the concert every day for weeks now, so you know he's excited. And although it's still several hours away, you can already feel your heart beating a little faster than normal.

As you're getting ready for the show at home, your friend calls to tell you that he's coming over in about an hour. Just so you don't forget later, you decide to get the tickets from your drawer. You open your top drawer where you remember leaving them, but they're not there. You search a little deeper in the drawer, but they're not there either.

You stop to take a breath and tell yourself to calm down. You know you put the tickets in a good place, but where? You start searching through your backpack. Books, folders, pens, but no tickets. You turn the bag upside down and shake it. Nothing but junk. Now you start getting worried. What if you lost the tickets? What's your friend going to think?

In a hurry, you look through the laundry. Maybe they're in a pocket somewhere? You find some pieces of paper, but no tickets. You go into your closet and start throwing things to the floor—no tickets. You're feeling upset at this point. Your hands start to shake a little. You think back to when you had the tickets and try to retrace your steps. You clearly remember putting them in your top drawer, so you search again. You inspect everything, but there are no tickets in this drawer. You look through your whole room, but they're nowhere to be found.

You run to the kitchen and start looking on the counters. You open all the cupboards and drawers. You have no idea why the tickets would be there, but you need to look somewhere. In fifteen minutes, your kitchen looks like a disaster area. But still no tickets! You run out into the driveway. Maybe the tickets fell out somewhere? You look in the grass, the bushes, underneath cars. But even if they did fall out, they probably wouldn't even be there by now. As you walk back inside in complete frustration, you feel as though you're ready to pull your hair out. You lost the tickets. And you obviously can't go to the show without them.

Suddenly, you hear a knock on the door. Your friend is early, probably because he's eager to get going. You can hear him humming outside. What are you going to tell him? He'll be crushed. Is there anything you can do? Maybe you should lie? But that probably won't solve anything. As you walk toward the door, you get ready to fess up, take the blame, and hope that everything will be okay. You open the door, ready for the worst.

As you are about to start telling him what happened, he yells "Are you ready?" and pulls out the two tickets from his back pocket. Your eyes get wide. You grab the tickets from his hand and fall to your knees. Your friend has the tickets! He's had them the whole time. You think back and remember that he wanted to show the tickets to another person, so he took them the other week. You can't believe you forgot. You don't think you've ever felt so relieved in your life. You sit down, shake your head, and put your hand on your chest. You begin to laugh, wiping the sweat from your forehead. You and your friend will get to go to the show after all. Things are going to be just fine.

As you try to forget what happened, you're actually even more thrilled about the concert than before. Your relief turns into elation. You want to shout to everyone just how great you feel. It's as though you just found the winning lottery ticket. You can appreciate going to the concert even more now, knowing that you were very close to not going at all. Your friend is dying to get to the show, and his euphoria is contagious. Both of you run out the door, turn up the stereo, and head off to the most thrilling show of your lives.

CONTROL VIGNETTE FEMALES

Imagine that it's Friday afternoon during the semester. You've been working hard all week and you've been looking forward to this weekend for quite a while. You and one of your friends have two tickets for a sold-out concert that's happening tonight. Both of you have been looking forward to this show for a long time. In fact, you had to bend over backwards to get the tickets. Your friend has been talking about the concert every day for weeks now, so you know she's excited. And although it's still several hours away, you can already feel your heart beating a little faster than normal.

As you're getting ready for the show at home, your friend calls to tell you that she's coming over in about an hour. Just so you don't forget later, you decide to get the tickets from your drawer. You open your top drawer where you remember leaving them, but they're not there. You search a little deeper in the drawer, but they're not there either.

You stop to take a breath and tell yourself to calm down. You know you put the tickets in a good place, but where? You start searching through your backpack. Books, folders, pens, but no tickets. You turn the bag upside down and shake it. Nothing but junk. Now you start getting worried. What if you lost the tickets? What's your friend going to think?

In a hurry, you look through the laundry. Maybe they're in a pocket somewhere? You find some pieces of paper, but no tickets. You go into your closet and start throwing things to the floor—no tickets. You're feeling upset at this point. Your hands start to shake a little. You think back to when you had the tickets and try to retrace your steps. You clearly remember putting them in your top drawer, so you search again. You inspect everything, but there are no tickets in this drawer. You look through your whole room, but they're nowhere to be found.

You run to the kitchen and start looking on the counters. You open all the cupboards and drawers. You have no idea why the tickets would be there, but you need to look somewhere. In fifteen minutes, your kitchen looks like a disaster area. But still no tickets! You run out into the driveway. Maybe the tickets fell out somewhere? You look in the grass, the bushes, underneath cars. But even if they did fall out, they probably wouldn't even be there by now. As you walk back inside in complete frustration, you feel as though you're ready to pull your hair out. You lost the tickets. And you obviously can't go to the show without them.

Suddenly, you hear a knock on the door. Your friend is early, probably because she's eager to get going. You can hear her humming outside. What are you going to tell her? She'll be crushed. Is there anything you can do? Maybe you should lie? But that probably won't solve anything. As you walk toward the door, you get ready to fess up, take the blame, and hope that everything will be okay. You open the door, ready for the worst.

As you are about to start telling her what happened, she yells "Are you ready?" and pulls out the two tickets from her back pocket. Your eyes get wide. You grab the tickets from her hand and fall to your knees. Your friend has the tickets! She's had them the whole time. You think back and remember that she wanted to show the tickets to another person, so she took them the other week. You can't believe you forgot. You don't think you've ever felt so relieved in your life. You sit down, shake your head, and put your hand on your chest. You begin to laugh, wiping the sweat from your forehead. You and your friend will get to go to the show after all. Things are going to be just fine.

As you try to forget what happened, you're actually even more thrilled about the concert than before. Your relief turns into elation. You want to shout to everyone just how great you feel. It's as though you just found the winning lottery ticket. You can appreciate going to the concert even more now, knowing that you were very close to not going at all. Your friend is dying to get to the show, and her euphoria is contagious. Both of you run out the door, turn up the stereo, and head off to the most thrilling show of your lives.

SHORT-TERM VIGNETTE MALES

Imagine that you are on vacation with your friends on a tropical island. It's the last day of your trip and you are sitting on the beach on a pleasant summer afternoon, sipping an exotic drink. The air is warm and pleasant, and you watch the waves as the sun begins to set. You have a book open, but you're not really reading it. Instead, you look around, relaxed and daydreaming. As you watch the people strolling by on the soft sand, you notice that everyone seems to be in a particularly good mood.

From behind you, you hear a voice say: "Wow, isn't that the most beautiful sunset you have ever seen?"

When you turn around, you are surprised to see that it's coming from a particularly attractive woman whom you have seen before. You remember noticing her a few days earlier at the hotel, when your eyes locked across the lobby. Since that time, you've seen her several times, but you have never had a convenient opportunity to talk with her.

Now she is standing right in front of you, and smiling warmly. "Mind if I join you for a few minutes?" she says.

At first you feel a bit awkward, but as you begin to talk, you realize that you feel incredibly comfortable with her. You share your thoughts about your week on the island, and you are both a little sad that your time in paradise hasn't been as exciting as you had hoped. And while you learn that she lives far away from you, it turns out that it's her last night on the island as well. Up close, she is even more attractive and charming than you remember. And she is wonderful to talk to. You find that everything she says is somehow fascinating, and you notice that when you talk, she listens carefully to everything you say.

An hour passes very rapidly and she notices that she's late for dinner with her friends. She suggests that maybe she'll just skip dinner with them and stay here with you, if you still want company. After all, she sees them all the time, but the two of you only have one evening together. You are only too glad to prolong the conversation. It is clear that she is enjoying your company immensely.

She suggests that the two of you go grab something to eat. Walking together, you notice that she's walking close to you and comfortably touching you on the arm when you say something that makes her laugh. When she's around you, your senses become heightened. Even when her hand touches yours by accident, you feel a tingle and a rush of excitement. You quickly glance at her eyes, waiting for her to look at yours. When she does, both of you smile and look away.

You end up in a little restaurant near the beach, and the two of you sit in a dark romantic corner in the back. By the candlelight, you notice the pleasant and soothing aromas from the kitchen. As the evening goes on, you realize you are having an absolutely wonderful time with this person, and that she is feeling the same way. The two of you order a dessert together and decide to share it. She suggests that after dinner, both of you should go for a walk on the beach in the moonlight. You have been dreaming about someone asking you that very question all week.

As you stroll out onto the sand, she reaches for your hand. You softly squeeze her hand in yours and your eyes meet once again. It's a little windy and she gets closer to you. Her body feels warm under the stars and she puts her head on your bare arm. You can hear that your heart is beating faster, and you feel excited. The sand feels cool and soft against your feet. A wave comes crashing on the beach and you both lightly trip and fall as you try to run away. Sitting in the sand and still holding her hand, you feel the coldness of the water on your feet. Both of your eyes lock again and your heart feels like it's about to stop. As you look at her beautiful face in the moonlight, her hand moves up to caress the back of your neck. You can feel your hairs begin to tingle. You lean in and the tip of your nose slowly touches hers as you continue to wander in each other's gaze. Finally, you close your eyes and her soft lips slowly touch yours for the first time. Although you know that you might never see her again, the kiss is filled with passion. Your embrace is flowing with the kind of desire that you have never felt. You squeeze her body tighter, and you can feel yourself getting excited as you begin to think of how to make this night be one of the most memorable of your entire life.

SHORT-TERM VINGETTE FEMALES

Imagine that you are on vacation with your friends on a tropical island. It's the last day of your trip and you are sitting on the beach on a pleasant summer afternoon, sipping an exotic drink. The air is warm and pleasant, and you watch the waves as the sun begins to set. You have a book open, but you're not really reading it. Instead, you look around, relaxed and daydreaming. As you watch the people strolling by on the soft sand, you notice that everyone seems to be in a particularly good mood.

From behind you, you hear a voice say: "Wow, isn't that the most beautiful sunset you have ever seen?"

When you turn around, you are surprised to see that it's coming from a particularly handsome man whom you have seen before. You remember noticing him a few days earlier at the hotel, when your eyes locked across the lobby. Since that time, you've seen him several times, but you have never had a convenient opportunity to talk with him.

Now he is standing right in front of you, and smiling warmly. "Mind if I join you for a few minutes?" he says.

At first you feel a bit awkward, but as you begin to talk, you realize that you feel incredibly comfortable with him. You share your thoughts about your week on the island, and you are both a little sad that your time in paradise hasn't been as exciting as you had hoped. And while you learn that he lives far away from you, it turns out that it's his last night on the island as well. Up close, he is even more attractive and charming than you remember. And he is wonderful to talk to. You find that everything he says is somehow fascinating, and you notice that when you talk, he listens carefully to everything you say.

An hour passes very rapidly and he notices that he's late for dinner with his friends. He suggests that maybe he'll just skip dinner with them and stay here with you, if you still want company. After all, he sees them all the time, but the two of you only have one evening together. You are only too glad to prolong the conversation. It is clear that he is enjoying your company immensely.

He suggests that the two of you go grab something to eat. Walking together, you notice that he's walking close to you and comfortably touching you on the arm when you say something that makes him laugh. When he's around you, your senses become heightened. Even when his hand touches yours by accident, you feel a tingle and a rush of excitement. You quickly glance at his eyes, waiting for him to look at yours. When he does, both of you smile and look away.

You end up in a little restaurant near the beach, and the two of you sit in a dark romantic corner in the back. By the candlelight, you notice the pleasant and soothing aromas from the kitchen. As the evening goes on, you realize you are having an absolutely wonderful time with this person, and that he is feeling the same way. The two of you order a dessert together and decide to share it. He suggests that after dinner, both of you should go for a walk on the beach in the moonlight. You have been dreaming about someone asking you that very question all week.

As you stroll out onto the sand, he reaches for your hand. You softly squeeze his hand in yours and your eyes meet once again. It's a little windy and you get closer to him. His body feels warm under the stars and you put your head on his bare arm. You can hear that your heart is beating faster, and you feel excited. The sand feels cool and soft against your feet. A wave comes crashing on the beach and you both lightly trip and fall as you try to run away. Sitting in the sand and still holding his hand, you feel the coldness of the water on your feet. Both of your eyes lock again and your heart feels like it's about to stop. As you look at his beautiful face in the moonlight, his hand moves up to caress the back of your neck. You can feel your hairs begin to tingle. He leans in and the tip of his nose slowly touches yours as you continue to wander in each other's gaze. Finally, you close your eyes and his soft lips slowly touch yours for the first time. Although you know that you might never see him again, the kiss is filled with passion. Your embrace is flowing with the kind of desire that you have never felt. You squeeze his body tighter, and you can feel yourself getting excited as you begin to think of how to make this night be one of the most memorable of your entire life.

LONG-TERM VIGNETTE MALES

Imagine that you're at home getting ready to go on a first date with a wonderful person whom you just recently met. Your roommate can sense that you're excited about the date and asks about how the two of you met. You think that the story about how you met is very sweet and romantic, so you decide to tell it to your roommate...

There you are, sitting around on campus after class. It's a pleasant early spring day, and you can smell the blooming flowers in the breeze. You have a book open, but you're not really reading it. You look around, relaxed and daydreaming. As you watch the people strolling by in front of you, you notice that everyone seems to be in a particularly good mood.

From behind you, you hear a voice say: "You don't look like you're studying very hard."

When you turn around, you're surprised to see a particularly attractive woman whom you have seen before. In fact, you remember noticing her on the first day of class, when your eyes locked across the classroom. Since that time, you've seen her around several times, but have never had a convenient opportunity to talk with her.

Now she is standing right in front of you, and smiling warmly. "Mind if I join you for a few minutes?" she says.

At first you feel a bit awkward, but as you begin to talk, you realize you feel incredibly comfortable with her. The two of you discover that you have a lot in common, including that both of you are currently single. When she hears this, she lights up. Up close, she is even more attractive than you remember. And she is wonderful to talk to. You find everything she says somehow fascinating, and you notice that when you talk, she listens carefully to everything you say.

An hour passes very rapidly, at which point she notices that she's late for class. She suggests that maybe she'll just cut class today, if you still want company. You are only too glad to prolong the conversation. It is clear that she is enjoying your company immensely.

She suggests that the two of you go grab something to eat. Walking together, you notice that she's walking close to you and comfortably touching you on the arm when you say something that makes her laugh. When she's around you, your senses become heightened. Even when her hand touches yours by accident, you feel a tingle and a rush of excitement. You quickly glance at her eyes, waiting for her to look at yours. When she does, both of you smile and look away.

You end up in a little restaurant near school, and the two of you sit in a dark romantic corner in the back. By the candlelight at your table, you notice the pleasant and soothing

aromas from the kitchen. As the evening goes on, you realize you are having an absolutely wonderful time with this person, and that she is feeling the same way. The two of you begin to talk a bit about your personal lives, and you realize that she is an especially kind and sensitive woman who really cares about others. Captivated by her beautiful face in the glimmering candlelight, you find yourself imagining what it would be like to be in a relationship with her. You haven't felt so comfortable with someone in a long time.

Several more hours go by and the waitress smiles when she mentions that the restaurant is closing. Apparently, she's noticed the romantic feelings between the two of you.

As you walk her home, you're amazed at what has happened in the last few hours. It's as though you're falling in love at first sight. In front of her door, she stops and looks at you with an intense gaze. You wonder if it would be appropriate to kiss, but nothing happens. She tells you that she hopes to see you again and your heart just melts. Your hands brush together, and your heart races as you begin to feel lightheaded. You lean towards one another and hold each other in a warm and loving embrace. As the evening comes to a close, you don't want to let her go, and you are already thinking about the next time you'll see her...

After that first wonderful encounter, the two of you have gone out on several more spectacular dates. During that time, you've met her friends and have learned a lot more about her as a person. You are amazed at what a wonderful woman she has turned out to be and you feel very fortunate that she approached you on that day at school. When your roommate met her last week, he was amazed at how wonderful she was. He was certain that you should go after her, which only confirmed your own feelings. At this point, you are sure that you would like to start a meaningful relationship with this loving and beautiful woman, and you are confident that you can make her feel the same way.

In fact, you're going to be seeing her again tonight. Although you've been out with her several times, you still get butterflies in your stomach and your heart begins to race each time before you see her. There's just something about her that always makes you feel comfortable and excited. You can't wait to see her and you know you're going to have a great time like you always do when you're together. You hope that tonight will be the night when the two of you officially become a couple. As you head out the door, you are filled with excitement and anticipation...

LONG-TERM VIGNETTE FEMALES

Imagine that you're at home getting ready to go on a first date with a wonderful person whom you just recently met. Your roommate can sense that you're excited about the date and asks about how the two of you met. You think that the story about how you met is very sweet and romantic, so you decide to tell it to your roommate...

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He suggests that the two of you go grab something to eat. Walking together, you notice that he's walking close to you and comfortably touching you on the arm when you say something that makes him laugh. When he's around you, your senses are heightened. Even when his hand touches yours by accident, you feel a tingle and a rush of excitement. You quickly glance at his eyes, waiting for him to look at yours. When he does, both of you smile and look away.

You end up in a little restaurant near school, and the two of you sit in a dark romantic corner in the back. By the candlelight at your table, you notice the pleasant and soothing aromas from the kitchen. As the evening goes on, you realize you are having an absolutely wonderful time with this person, and that he is feeling the same way. The two of you begin to talk a bit about your personal lives, and you realize that he is an especially kind and sensitive man who really cares about others. As he talks about his ambitions, you find yourself imagining what it would be like to be in a relationship with him. You haven't felt so comfortable with someone in a long time.

Several more hours go by and the waitress smiles when she mentions that the restaurant is closing. Apparently, she's noticed the romantic feelings between the two of you.

As he walks you home, you're amazed at what has happened in the last few hours. It's as though you're falling in love at first sight. In front of your door, he stops and looks at you with an intense gaze. You wonder if it would be appropriate to kiss, but nothing happens. He tells you that he hopes to see you again and your heart just melts. Your hands brush together, and your heart races as you begin to feel lightheaded. You lean towards one another and hold each other in a warm and loving embrace. As the evening comes to a close, you don't want to let him go, and you are already thinking about the next time you'll see him...

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Appendix F

Primary hypothesis using all seven dichotomous variables

MANOVA was performed on the musical rating variables to test the effects of mating primes and sex on the creation of a novel piece of music. For this set of analyses musical ratings were calculated for each of the seven variables by averaging scores for all 82 raters. The overall multivariate test (Wilks' Lambda) was not significant $F(14, 158) = .962, p = .498, \eta^2 = .78$. Within the MANOVA, omnibus univariate tests were significant for the main effect of sex for Expressiveness $F(1, 86) = 3.956, p = .050, \eta_p^2 = .044$; Imagination $F(1, 86) = 3.954, p = .050, \eta_p^2 = .044$; Complexity $F(1, 86) = 5.181, p = .025, \eta_p^2 = .057$; and Rhythm $F(1, 86) = 4.370, p = .040, \eta_p^2 = .048$. Musical ratings for Quality, Appealingness, and Melody did not significantly differ with regard to sex. No significant interactions or main effects for mating primes were identified. Means and standard deviations by mating prime and sex are displayed in Figures *a-g* (below).

We re-ran this MANOVA excluding the eight participants who reported or suffered from mood disorders. The overall multivariate test (Wilks' Lambda) again was not significant $F(14, 144) = .943, p = .515, \eta_p^2 = .084$. Univariate results indicated main effects of sex for Quality $F(1, 78) = 4.627, p = .035, \eta_p^2 = .056$, Expressiveness $F(1, 78) = 4.434, p = .038, \eta_p^2 = .054$; Imagination $F(1, 78) = 4.837, p = .031, \eta_p^2 = .058$; Complexity $F(1, 78) = 5.955, p = .017, \eta_p^2 = .071$; Rhythm $F(1, 78) = 5.205, p = .025, \eta_p^2 = .063$; and Melody $F(1, 78) = 4.542, p = .036, \eta_p^2 = .055$. Musical ratings did not significantly differ for Appealingness.

To investigate if mating primes had specific effects on musical performance planned contrasts were conducted comparing group means for musical ratings. We first examined

the effect of mating primes on men. Our first hypothesis stated that men primed to think about short-term or long term mating would have higher musical ratings than men in the neutral condition. Planned contrasts revealed that men primed for short-term or long-term mating did not score higher than men in the neutral condition on any of the seven musical ratings.

We then examined the effect of mating primes on the seven dichotomous variables for women. This group of analyses predicted that women primed to think about long term mating would have higher ratings on the musical production task than women in the short-term or neutral conditions on musical ratings (H2). Contrasts revealed that women in the long-term mating group performed better than women in the short-term mating group for Appealingness, $t(44) = -2.648, p = .011, d = .94$; Expressiveness, $t(44) = -2.740, p = .009, d = .97$; Imagination, $t(44) = -3.022, p = .004, d = 1.06$; Complexity, $t(44) = -2.883, p = .006, d = 1.02$; Rhythm, $t(44) = -2.760, p = .008, d = .97$; and Melody, $t(44) = -2.792, p = .008, d = .99$. Contrasts also revealed that women who were primed to think about long term mating had higher ratings on the musical production task as compared to women in the neutral condition for Appealingness, $t(44) = -2.127, p = .039, d = .29$; Imagination, $t(44) = -2.140, p = .038, d = .29$; and Melody $t(44) = -2.098, p = .042, d = .28$.

Our next hypothesis compared men and women's performance after reading a short-term mating prime. We predicted that in the short-term condition men primed to think about short-term mating would have higher ratings than women on the musical production task (H4). As predicted, men had higher ratings than women in the short-term mating condition. These differences were found for Expressiveness, $t(29) = 2.249, p = .032$,

$d = .30$; Imagination, $t(29) = 2.389, p = .024, d = .32$; Complexity, $t(29) = 2.563, p = .016, d = .34$; Rhythm, $t(29) = 2.214, p = .035, d = .30$; and Melody, $t(29) = 2.173, p = .038, d = .29$.

Men and women's musical ratings did not differ in the short-term condition for Quality or Appealingness. Means and standard deviations for the seven dichotomous rating items are displayed in Figures *a-g*.

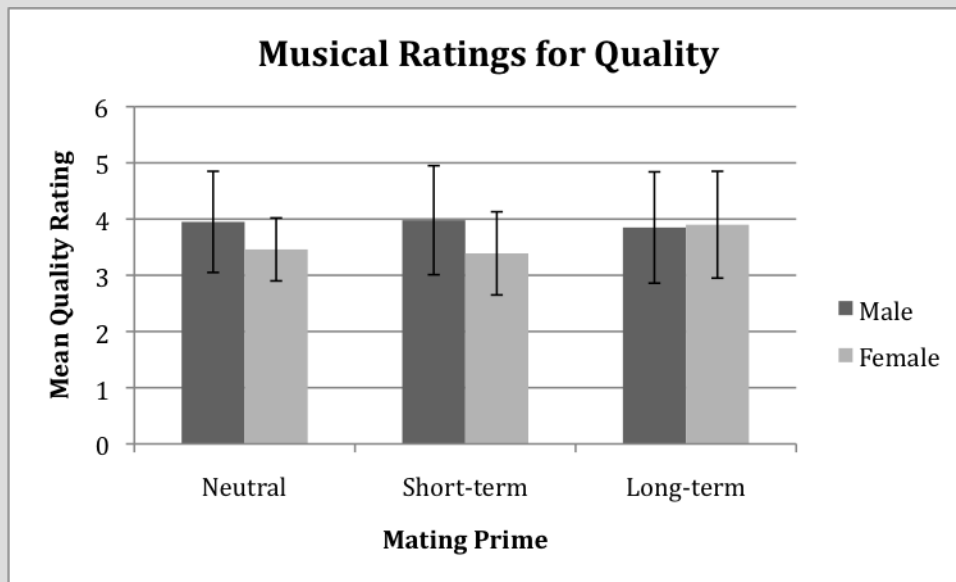


Figure *a*. Quality ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

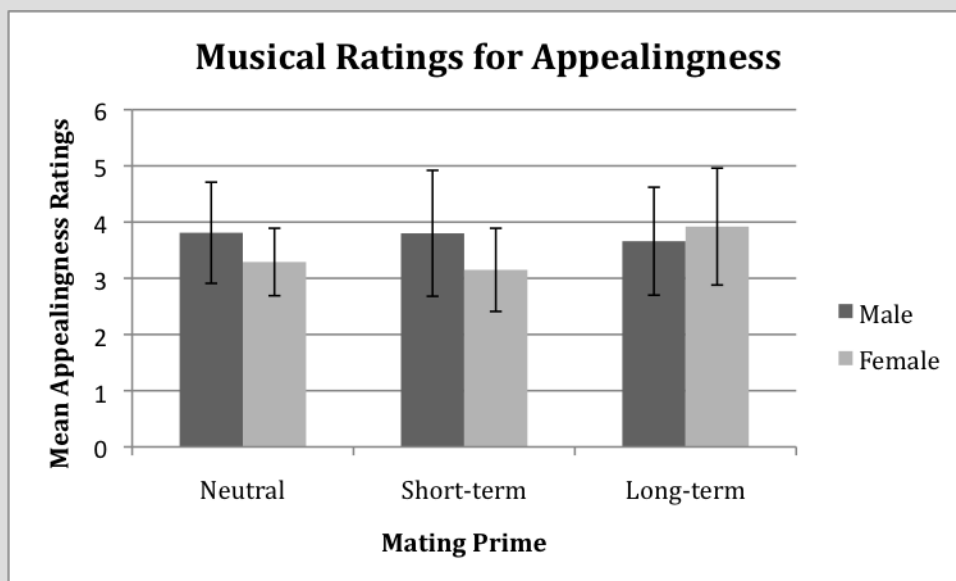


Figure b. Appealingness ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

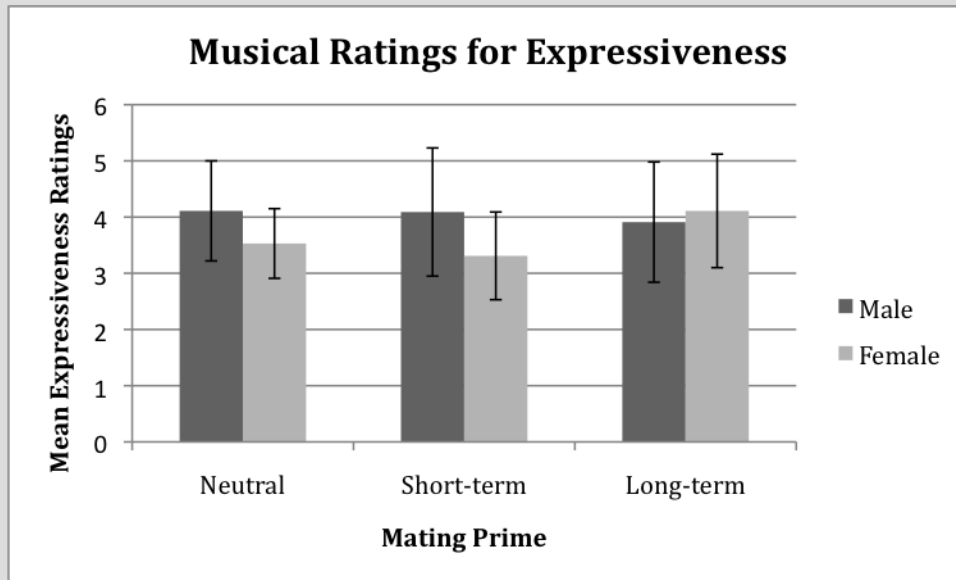


Figure c. Expressiveness ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

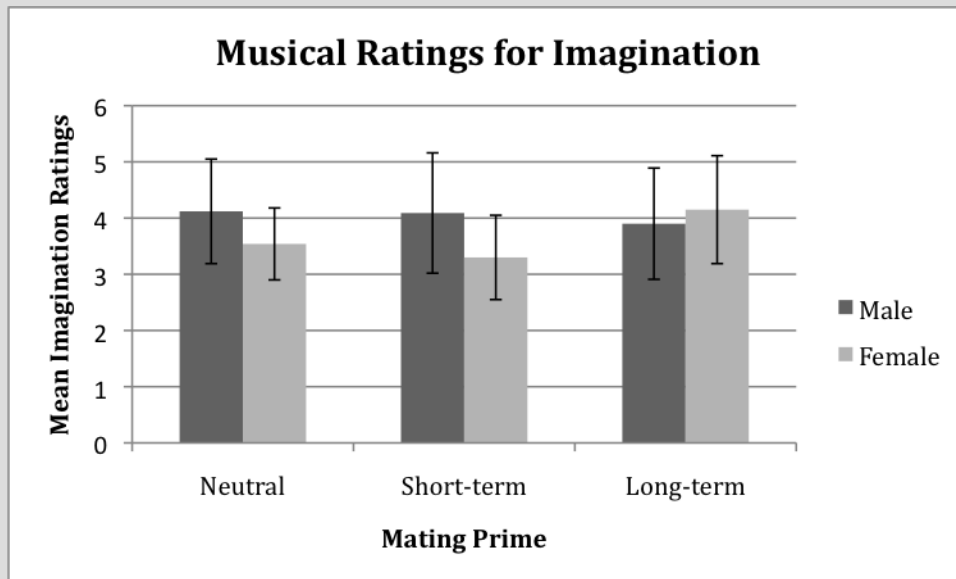


Figure d. Imagination ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

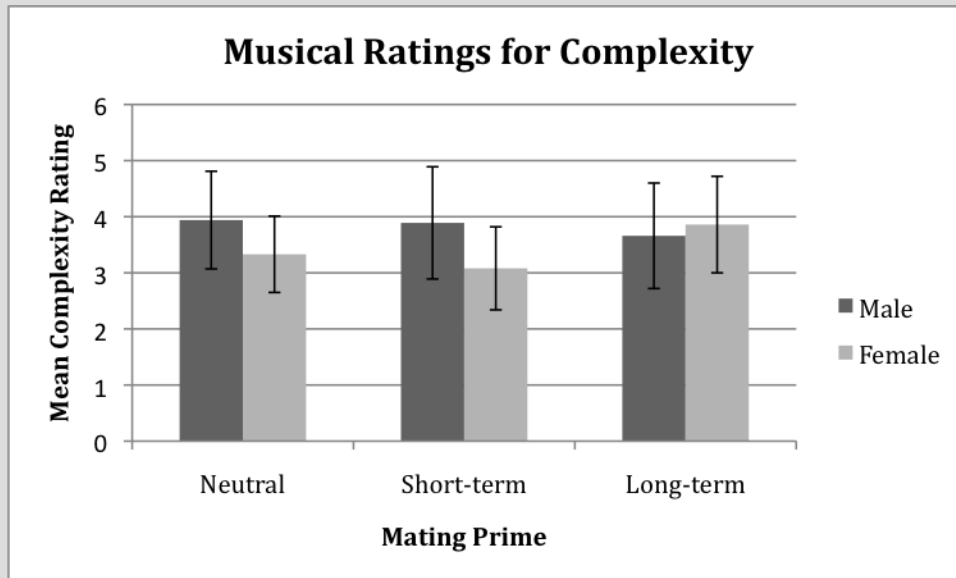


Figure e. Complexity ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

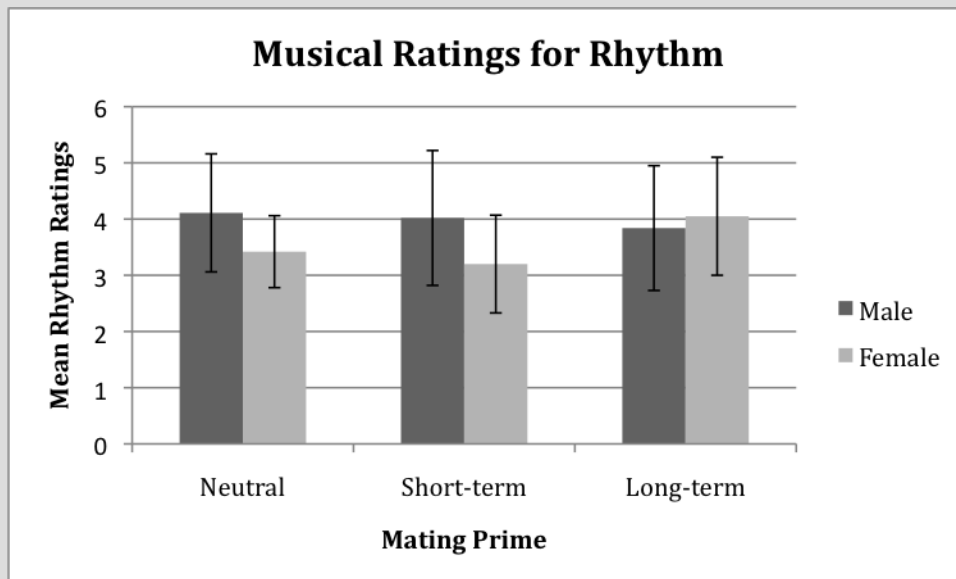


Figure f. Rhythm ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

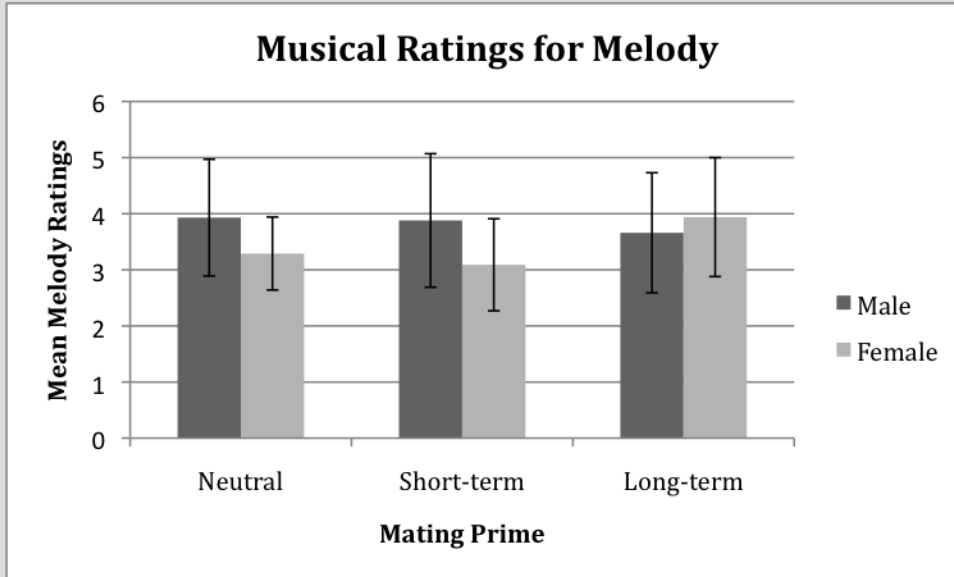


Figure g. Melody ratings for men's and women's novel compositions depending of the type of mating prime with standard error bars.

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