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Cover Page Footnote

The present paper is dedicated to Luciana Bottoni

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Why We Experience Musical Emotions:
William Gardiner's "The Music of Nature" Revisited

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Abstract

This paper focuses and expands on the ideas of William Gardiner, an amateur musician who was the first to propose that human emotions experienced in music listening might be inspired by "the sounds of nature." His book has been ignored for almost two centuries. We revisit his hypothesis from an evolutionary psychology approach. This contribution reviews environmental psychology and musical studies which focus on emotional reactions to basic musical cues such as pitch, timbre, and loudness, and also, on animal communication studies. Reported literature confirms the hypothesis that our ancestral soundscape might have shaped, at least in part, the basic emotions that organize our behavioural responses to environmental stimuli.

Keywords: William Gardiner, environmental psychology, music cognition, evolutionary psychology

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Introduction

William Gardiner (1771-1853) was an amateur musician and hymn composer and a foreign member of the Accademia di Santa Cecilia (Middleton, *Wikisource*). Gardiner was familiar with Zoonomia (1794-2005), the book by Erasmus Darwin (1731-1802), grandfather of Charles Darwin and Francis Galton. Gardiner was a vegetarian strongly influenced by the new ways that many enlightened minds at the time, Gomperz (1824/1992) among others, began to regard non-human creatures, both wild and domestic. In the United Kingdom, the first animal protection legislation was presented to the Parliament as early as 1800, but it was not until 1822 that the first bill was passed. The passage of this legislation was quickly followed by the establishment of a key and enduring animal welfare institution, the Royal Society for the Prevention of Cruelty to Animals (RSPCA), tasked with an educative and enforcement role (White 2016). With regard to respecting and loving animal life, Gardiner wrote: “The summer bird-catchers are the most barbarous, who entrap only singing birds, and take them without regard to their having youngs - which may perish by their absence - or to that harsh change from the enjoyment of summer sunshine and pleasure, to the captivity of a cage” or, referring to the Londoners’ habit of keeping dogs and cats without providing for their food: “… if people would but take the trouble of saving them (cats and dogs), the useless remains of their own dainty meals, or now and then purchasing them food sold in the streets, many a poor faithful animal might be spared a painful life and miserable death” (1832).

The above passages are quoted from his book, *The Music of Nature; or An Attempt to Prove that what is Passionate and Pleasing in the Art of Singing, Speaking, and Performing upon Musical Instruments, is Derived from the Sounds of the Animated World, which also contains curious and interesting illustrations* (1832). In the preface, we read:

> The author of the following pages has been in the habit of listening to sounds of every description and that with more than ordinary attention; but none have interested him so much as the cries of animals and the song of birds. In the busy world, or in quiet and repose, he has amused himself with taking down these **germs of melody** … The instances here recorded are a faithful transcript of the voice of Nature, and it will strike every one, that music has had its origin in these simple and immutable expressions …”, (emphasis added)

Gardiner listened to the sounds of insects, including bees; songbirds; domestic mammals such as dogs, cats, and cows; and sounds we would presently call *geophonia* (Krause 2012), such as those generated by thunderstorms, falls, and creeks:

> Perhaps of all noises which are augmented by continued reverberations, none are more appalling than the experiment of rolling a portion of rock into Heldon Hole, in Derbyshire. … to hear the thundering mass fall from cavern to cavern, wakening the frightful echoes … fills the mind with terror and dismay.

Gardiner transposed many animal sounds (blackbird, hen, cat in the night, game cock, cow, and many others) into musical scores that can be found in his book, and compared some of those transcriptions to similar scores of known musicians. However, Gardiner’s aim was far more advanced than a descriptive task. As suggested by the title of the book, he aimed at demonstrating that emotions aroused by music, a unique and culturally evolved human artifact (Brown, 2000;

Darwin, 1871; Merker, 2000; Miller, 2000; Mithen, 2006; Richman, 2000; Trainor, 2010), are shaped by environmental natural sounds. The book is written in the scientific descriptive style of the times (see also Erasmus's book), listing all the available knowledge and adding oral reports and/or anecdotes.

Certainly, the 21st century scientist would not find the scientific "demonstration" or "proof" that Gardiner promised in his title. However, the idea that emotions experienced during music listening, or at least some of them, might have roots in the ancestral soundscape where *Homo sapiens* evolved for nearly 90% of their existence (Stringer, 2016; Tattersall, 1995), and that these environments have shaped humans' emotional responses (Barkow, Cosmides, and Tooby, 1992), is intriguing if we consider the important emotional role that natural soundscapes have in our lives.

Apropos, Lenti Boero and Bottoni (2008) defined the predisposition of our auditory system to generate conscious "aesthetic" and/or emotional responses to natural sounds as " *intrinsic musicality*." Taking into account an evolutionary viewpoint, they hypothesized that music could cloak a universal and adaptive code determining musical preferences and that this code might have been shaped, at least in part, by our evolutionary past. In the present contribution, some of the suggestions from Gardiner are examined in light of evolutionary psychology, environmental psychology, and music emotion studies.

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Soundscape Preferences

Much of the information about human responses and reactions to natural soundscape comes from environmental psychology and architectural urban design studies, as well as from the insights that musicians, the sound artists "par excellence," report to us. According to Schafer, a Canadian musician who in the late 1960s and early 1970s launched the World Soundscape Project, water, for example, is a most pleasurable sound for humans. In his book, *The Tuning of the World* (1977), he devotes many pages to water in its many forms (seas, lakes, rivers, streams, rain) and asserts: "Given the chance, probably all men would live at the edge of the element, within earshot of its moods night and day." Krause (2012), a musician and a naturalist, reports on the collective memory (and nostalgia) for the sound of the *Celino Waterfall*, which was still present among the *Wy-am* Native Americans many years after the Dalles Dam was erected. Many people find natural environmental soundscapes (ocean waves, rainfall, etc.) to be relaxing and pleasant, to the point that recordings of such sounds are marketed to aid sleep and relaxation (McDermott, 2011).

Moreover, Anderson et al. (1983) reproduced eighteen different sounds (e. g., songbirds, construction equipment, automobiles, aircraft, wind) at field sites ranging from a forest to a downtown street and found that wind and songbirds had enhancing effects on evaluations of the heavily wooded natural and residential sites while the human-engineered sounds had detracting effects on the same sites. In a field study conducted in Sheffield, England, inside urban squares where both artificial and natural sounds could be heard, Yang and Kang (2005) found that the sounds of water and the twittering of birds were preferred by 80% and 78%, respectively, of the subjects. Forty-seven percent preferred church bells and 43% preferred music played on the street. Analogously, in an outdoor setting situated in a culturally distant urban environment (Yokohama City, Japan), Tamura (2002) found that many subjects from a total of 1240 participants of both sexes preferred sounds related to nature, such as birds and chirping of insects in autumn. The croaking of frogs and droning of cicadas had the highest rank for preference over annoyance (72.6 over 1.0; 59.6 over 2.6 respectively for birds and insects and frogs) and the whisper of leaves had a preference over annoyance rating of 43.6 over 0.8. Interestingly, murmurs of water streams and sea waves had 62.9 over 0.6 and 57.0 over 3.5 preference over annoyance respectively, but water supply and drainage sounds in bathrooms elicited 0.9 preference over 15.6 annoyance. This study suggests an important difference in the appreciation of the quality or type of the water sound produced. In a laboratory experiment, natural sounds (stream, thunderstorm) received the maximum mean of affective value assigned by 75 participants. Also, natural sounds increased the appreciation of both natural and artificial settings (Carles, Lopez Barrio, and Vicente de Lucio 1999). In a study conducted in Tianjin, China Jia, Ma, and Kang (2020) asked 2504 respondents to recommend the soundscapes worthy of preservation in the city. This first survey indicated that the majority of soundscapes suggested for preservation were located in urban parks and historic districts with respective proportions of 66% and 20%. In the second stage of the study, 23 architecture students of the local university participated in a soundscape walk in order to explore the characteristics of soundscapes worthy of preservation. The top three sound source categories of these soundscapes were social/communal sounds (talking, bells, laughter, and sounds from human activities), animal sounds (birdsong and sounds from non-domesticated animals), and water sounds.

A questionnaire surveying 400 users in four urban green spaces in Rostock, Germany, showed that street traffic sounds were the least preferred, but in a dominating position either in perceived occurrences or loudness, while bird song and water sounds were the most preferred sounds (Liu et al., 2018). Qiu, M. Sha, J. and Utomo S. (2021) conducted a study at the Burleigh Heads Beach National Park, Australia, whose best well-known attractions are the various natural soundscapes both *geophonic* (wind and sea waves) and *biophonic* (birds and insects). The study compared the restorative effects of the soundscape between pre-COVID-19 and post-COVID-19 subjects. The authors demonstrated that the acoustic environment of the post-COVID-19 period with a higher presence of natural elements presented lower sound levels and more diverse sound events, which tended to be positive for the mental health of visitors.

A higher level of appreciation was measured when employing a *serenity* scale -- natural and higher aesthetic values were found for natural (birds, water, wind, crickets) vs human-produced *sounds* (helicopter, human steps, talks, and laughter). The various sound sources were singularly evaluated in a study conducted in the *Peteurey Forest* near *Courmayeur, Valle d'Aosta*, Italy (Lenti Boero, unpublished). All the above studies suggest that in laboratory and outdoor urban environments, where both natural and human-produced sounds could be heard, natural sounds -- especially water, bird and insect sounds -- are particularly preferred.

With regard to birds, it is noticeable that songbirds have been a privileged kind of "natural instrument." Many songbirds, such as the canary (*Serinus canaria*) (Birkhead, Schulze-Hagen, and Kinzelbach, 2004) and the Bengali finch (*Lonchura domestica*) (Svanberg, 2008), among others, were domesticated and subsequently selected for their singing quality and not for a utilitarian aim as were hens, turkeys, pigeons, geese, etc. (Catchpole and Slater, 1995). Baptista and Keister (2005) define birds as quintessential vocalists, whose performance might be heard in all the environments on our planet, such as seashore, desert, or rainforest. In closing, the above literature suggests that

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songbirds, together with water, and in some cases insects, are the most preferred sounds in urban places and, in general, are favored even over human-produced musical sounds.

Is Gardiner's Hypothesis Supported by Music Studies?

Loudness

In a natural environment the loudness of a sound provides information about the location of a concealed presence. The louder the sound the nearer the emitter (Tajadura-Jiménez et al., 2010), thus a loud sound may signify danger and induce fear or arousal. In his famous Bolero, Maurice Ravel uses the crescendo as an expressive musical tool for inducing arousal in the listener, showing that loudness and pitch were concurrent in the artist's view. In the previous section addressing soundscape preferences, water is reported as the most preferred sound. However, other studies suggest that high volume or other characteristics might negatively affect its appreciation. For example, Tamura (2002) found that the non-natural sound produced by water supply and drainage in bathrooms was considered as most annoying by 15.6% of the subjects, and was favored by only the 0.9% of the same subjects that also rated the natural sound of water as the most pleasant. Ekman, Lunde and Nilsson (2015) evaluated the preference of 57 listeners for the sounds produced by 32 fountains from 28 different sites in Stockholm. In their study, recordings from fountains with jets or large volumes of downward falling water, having a higher sound pressure level (perceived as loudness), obtained low pleasantness scores. Their subjects defined those sounds as having a loud steady-state and waterfall-like sound. Conversely, recordings from small fountains with one or few small rising jets obtained high pleasantness scores and were defined as having a *purling-rippling* sound character. Those results are in accordance with an evolutionary psychology view of habitat sound preferences, because this "purling-rippling" sound character is typical of running water, and is an indicator of both safety and richness in food sources (Tonolla, Lorang, Heutschi, and Tockner, 2009). Fittingly, the sound of an alpine stream heard in its natural context is rated, not surprisingly, as being more pleasant than the sound of cars or helicopters (Lenti Boero, unpublished).

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Pitch

An evolutionary psychology interpretation of our sound preferences predicts that low-pitched sounds emitted by large, potentially dangerous animals should be associated with fear and anxiety, while high pitched sounds produced by small animals should be associated with happiness or joy (Lenti Boero and Bottoni, 2008). Pongràcz et al. (2006) showed that three different groups of subjects rated high pitched barks as less aggressive than the barks with medium or low pitches; in addition, the barks with short inter-bark intervals received the highest scores for aggression. The fact that the three groups of subjects (owners of a typical Hungarian dog breed, owners of dogs of different breeds, and non-dog owners) had different previous experiences with dogs, but showed only minor differences in the rating of barks, suggests that some intrinsic peculiarity of the sound itself might have been reacted to.

In an effort to differentiate between the effects of pitch on sound preferences, Lenti Boero et al. (2009) presented two samples of small mammalian vocalizations (gibbon courtship duets and marmot alarm whistles), two samples of songbirds (canary and chaffinch courtship songs), and human sounds (infant cries, babbling and singing human females) to 74 voluntary subjects of both sexes, aged 10 - 63 years. Results showed that 38% of the subjects defined mammalian sounds as "harsh or aggressive" and only 5% of them used this term for bird sounds. In contrast, bird sounds were considered "warm or sweet" by 57% of subjects, while only 14% of them used those terms for mammalian sounds. Beyond this semantic definition, sounds were rated for their aesthetic quality and while employing two Likert scales: gaiety vs uneasiness, and serenity vs anxiety. The mean score for aesthetic quality was significantly lower for mammals in contrast to birds. Songbirds obtained significantly higher scores than mammals in the gaiety/uneasiness evaluation.

Analogous results were found in music studies. For example, Chau, Gilburt, Mo, and Horner (2017) compared the effects of pitch and dynamics of the note C (i.e., *Do*, in Italian notation) played on various instruments. Twenty-seven subjects heard a total of 28 notes (14 notes × 2 dynamic levels). The researchers compared the effects of various frequencies played on a violin, the viola, a cello and a double bass (Pierce 1988). Each short stimulus was played in one of two dynamic levels, *forte* and *piano*, (loud and soft). Eight out of ten emotional responses and categories showed significant effects of pitch. For the present contribution only results regarding basic emotions (Panksepp, 1998) are reported. Happiness increased with pitch; anger was stronger for loud notes and decreased with pitch; fear was strongest in the lowest and highest registers and was not affected by dynamics (*forte* and *piano*). Similar results were found with the same study paradigm conducted with a piano (Chau, Mo and Horner, 2016).

Jaquet, Danuser, and Gomez (2014) adopted the bi-dimensional model of valence and arousal and investigated how manipulations of pitch level might affect felt emotions. Their 49 subjects listened to four one-minute classical piano excerpts (from Fauré, Chopin, Beethoven, and Burgmüller) in major and minor keys. Each excerpt was presented at three different pitch levels (one octave lower than the original version, the original version, and one octave higher than the original version). Results showed that pitch level increasing from -1 octave to +1 octave made valence ratings more positive with a linear and quadratic trend. Also, the valence ratings of musical excerpts in the -1 octave variant were significantly lower than the valence ratings of musical excerpts without octave modification and musical excerpts in the +1 octave variant ($p < .001$, $d = -0.87$).

Noise

Acousticians define white noise as a complex sound covering the entire range of audible frequencies that casually fluctuate over time (Frova, 1999). According to Schafer (1977), noise in our soundscape is mostly associated with the industrial revolution. However, geophonic sounds such as erupting volcanoes (Matoza et al., 2019), earthquakes (Tosi, Sbarra, and De Rubeis, 2012), and sea waves (Akulichev and Bulanov, 2018) also produce noise. There are some exceptions. Although generally speaking the sound of running water is considered white noise, Tonolla and colleagues (2009), inspired by the fact that "the physically generated sound of the flowing water of rivers has captivated people for centuries as expressed in rhythmic poems and lyrics," were one of the first to quantify acoustic signals related to *hydrogeomorphological* parameters. While inducing turbulence in flowing water they found that by manipulating different parameters -- water velocity, relative submergence, and flow obstructions -- fairly distinct sounds were generated.

In a pilot experiment, 17 expert musicians were asked to report the emotion felt while listening to the sound of a small river and of the volcano Arenal. In this experiment, 11 subjects (92%) felt fear, loneliness, aggressivity, and aversion, when listening to the volcano sound audio sample, while 10

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(83%) reported joyfulness and curiosity when listening to the river sounds (Lenti Boero and Habegger, unpublished).

Physiological studies show that the mammalian brain has a strong preference for periodic sounds (Langner and Ochse, 2006). Furthermore, psychophysical experiments have shown that the human brain has a natural preference for harmonic sounds.

Musicians and film-makers profit from the aversiveness of nonlinear sounds in order to manipulate sounds to create nonlinear analogues in order to shape emotional responses (Blumstein et al., 2010). Contemporary composers believe that nonlinear phenomena have robust potential for both composition and performance and might occur in the sound production of extra-normal extended techniques for both voices and musical instruments (Edgerton et al., 2003; Tsai et al., 2010).

Interestingly, animal sounds of all taxa (including humans, both adults and infants) produce a variety of nonlinear phenomena -- sounds produced by the desynchronization of a sound production system, such as subharmonics, biphonation, and deterministic chaos -- that vary according to the specific emotional reactions felt (Darwin, 1872; Morton, 1977; Wilde et al., 1998). Nonlinear phenomena appear in negative states such as distress, fear, threat, and arousal, and in turn, induce responsiveness in conspecifics, as many animal studies demonstrate [yellow-bellied marmots (*Marmota flaviventris*), Blumstein and Récapet 2009; white-crowned sparrows (*Zonotrichia leucophrys ssp. oriantha*), Blesdoe and Blumstein 2014; and domestic dogs (*Canis familiaris*), Taylor, Reby, and McComb, 2010]. Distress vocalizations of many types of infant mammals, including non-human primates and humans, also include nonlinear phenomena (Lingle et al., 2012). In human infants, the higher the stress level the higher the amount of nonlinearities over the melodic part of cries (Lenti Boero et al., 1998; Facchini et al., 2005). In a pilot experiment contrasting the rated quality of infant cry with early babbling, 14 of 17 adult subjects (82%) defined the infant cry as "aggressive" or "harsh," but only 18% of the subjects chose this definition for babbling, an admitedlly pleasant vocalization (Papoushek, 1992). That is, 65% of the subjects judged early babbling as "warm" or "sweet" (Lenti Boero and Bottoni, 2009a).

Sadly, coliqui infants and their prolonged cries deeply affect the emotional state of mothers and enhanced fantasies of abuse in 70% of the interviewees, and even infanticide (26%), during the colicky episodes (Levitzky and Cooper, 2000). *Nonlinearities are also present in adult human sounds* (Titze, 1994), *and might flexibly communicate both formidability and intention to attack, suggesting they are not a mere byproduct of loud vocalizing, but rather an informative acoustic signal well suited for intimidating potential opponents* (Anikin et al., 2021). Acoustically, nonlinear sounds are perceived as "harsh, rough, sharp" and are judged as unpleasant. The cawing of crows heard in an outdoor environment was rated as pleasant only by 5.7% of subjects, in contrast with a 72.6% pleasant rating of twittering songbirds (Tamura, 2002).

In general, soundscapes composed of many sounds are the most appreciated (Oba, 1994, 1995). The abundance and variety of sounds might have been an indicator of the occurrence of many potential prey species for our ancestors (Lenti Boero and Bottoni, 2008), also indicating the absence of danger. Even the casual forest wanderer knows that any abrupt perturbation of the "animal orchestra" induces silence (Krause, 2012; Lenti Boero pers. obs.).

Discussion

To our knowledge, William Gardiner was the first to propose the testable hypothesis of the existence of an emotional relationship between natural sounds and music. When he wrote his book, scientific knowledge about human evolution and our long-standing relationship with the natural environment (Tattersall, 1995) was yet to come. Charles Darwin's books were the foundation for both evolutionary biology and evolutionary psychology when published 27 and 39 years later (Darwin, 1859, 1871).

Lenti Boero and Bottoni (2008) proposed that our evolutionary history shaped, at least in part, our sound preferences and our predisposition to respond affectively to a variety of sounds, priming aesthetic and emotional feelings toward sound appreciation or avoidance. Research on the emotional reactions to the natural soundscape is in its infancy (McDermott, 2011) and is still lacking in adequate experimental work (Lenti Boero, in press). This is in contrast with the copious literature regarding landscape appreciation (Orians and Heerwagen, 1992; Herzog, 1985; Kahn, 2001; Kaplan and Kaplan 1989; Kaplan et al., 1989; Kaplan, 1992; and Tuan, 1984), and the primal fear (genetically predisposed?) toward scorpions, spiders, and snakes (Hoelh et al., 2017; Kawai and He, 20016; and Vetter et al., 2018).

We know that emotion-learning circuits in mammalian brains, including humans (Striedter, 2005), do generate adaptive behavioral responses to environmental challenges (Panksepp, 1998), thus we might expect the presence of emotional reactions to incoming acoustic signals prompting us to organize appropriate responses.

The present paper is an attempt to verify, at least in part, Gardiner's proposal, in light of what we know about our ancestral origins, characterized by the presence of water in the form of springs, running water in a forest or a clearing (Clayton et al., 2013; Cuthbert and Ashley, 2014; Rose and Marshall, 1996; Ashley et al., 2010; and Magill et al., 2016), or in the form of a calm lake surrounded by open savannah (Tattersall, 1995). The engulfing soundscape of our ancestors was rich in pleasant sounds -- crickets and grasshoppers, frogs and toads, sognbirds (Marler, 2004; Slabbekoorn and Smith, 2002) -- as well as unpleasant sounds, such as growls from big predators, that must have been perceived as threatening and scary for humans (see Fig. 1). Some of those sounds can be heard, even today, in savannah and forest environments (Skeoch and Koscha, n. d.).

We shall profit from many interdisciplinary fields in order to fully test Gardiner's proposal: landscape ecology, environmental and music psychology, and psychoacoustics. Studies reported in the present review seem to confirm the idea that a kind of "intrinsic musicality" is at work when we evaluate both natural and musical sounds (Lenti Boero and Bottoni, 2008). Certainly, we need many more experiments and comparisons, but while summarizing the literature reported in the present review, we could say that it does fit an evolutionary psychology hypothesis. Water is fundamental for our survival, and its sounds are frequently evaluated and reported as highly ranked in all the studies reviewed. Water, potentially, can also be dangerous, such as in the case of floods, and several studies report less appreciation of loud water sounds and waterfalls. Birds are small, innocuous animals uttering high-pitched, melodious sounds and are among the most preferred natural sounds in environmental studies.

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An evolutionary approach and hypothesis can also make use of consistent analogies between natural sounds and music appreciation. To reiterate, low-pitched dogs' barks are considered more aggressive than higher-pitched ones (Pongràcz et al., 2006), while sound excerpts of small mammals are less preferred in than songbirds (Lenti Boero et al., 2009). Analogously, low-pitched C, played by both bowed string instruments and pianos, elicit more anger, especially loud notes, whereas happiness increases with pitch, and in the lowest and in the highest registers, fear is often reported. This latter finding is the only one that does not fit into the hypothesis and thus needs a more thorough interpretation (Chau, Mo, and Horner, 2016; Chau, Gilburt, Mo, and Horner, 2017). All the above studies reported that nonlinearities and noise in sound signals induce aversion and arousal in humans and in other animal species.

To reiterate, physiological studies show that the mammalian brain has a strong preference for periodic sounds (Langner and Ochse, 2006). We also know that our brain was built on an architectural design common to all vertebrates (Streidter, 2005) and that subcortical circuits organize our behavioral responses to environmental challenges (Panksepp, 1998). Logically speaking, and according to Panksepp and Bernatzky (2002), those circuits are the foundation of emotional reactions to music in vertebrate species, including humans.

Human subjects speaking tonal and non-tonal languages are equally able to reliably identify higher levels of arousal in vocalizations of nine species representative of all classes of terrestrial animals: human, giant panda, hourglass treefrog, African bush elephant, black-capped chickadee, domestic pig, common raven, and barbary macaque (Filippi et al., 2017). This suggests a deep attuning with at least some environmental sounds, as an evolutionary psychology hypothesis would predict. In conclusion, Gardiner's book was written almost two centuries ago. This paper aims at revisiting his proposal viewed from an evolutionary psychology perspective. Some of these findings may assist in music education (Lenti, 2013 a, b; Shevock and Bates, 2019) and in conservation efforts: we know that the expansion of the anthropocene eliminates or puts in danger many naturally occurring sounds (Krause, 2012; Lenti Boero, 2010; and Pavan, 2017).

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Cover photo source: *Tumblr*

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Fig. 1. An artist's rendition of an early human habitat in East Africa 1.8 million years ago. Illustration: M.Lopez-Herrera via The Olduvai Paleoanthropology and Paleoecology Project and Enrique Baquedano. https://www.rutgers.edu/news/early-human-habitat-recreated-first-time-shows-life-was-no-picnic#.VuKq2eYufdV