The Human Passion for Music

*（心潮澎湃之于音乐何为）*

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# Definition（研究释义）

音乐，一门在人类文明中普遍存在的技艺。若以进化论的视角去解读，或许能知道：

“当我们在享受音乐时…”

——此种“**享受**”，何为？

大脑本身发育有奖励机制（产生愉悦感）的功能，问题是当我们听/制作有某种特殊属性的音乐时所产生反应的奖励机制是如何被进化出来的？最原初的进化先导性可能与语言对人类社会的重要性有关；利用好声音本身的特性（如纯净度、共鸣、丰富度及节奏）能够在交流时使表意更完整。有说法认为，以刺激大脑中能加强口头表达能力和学习类似声调语气区域的发育，在奖励机制与这些特征联系作用是进化中的选择。音乐还与其他生物适应性行为有关，例如休闲娱乐、社会凝聚力和性选择。音乐作为一种超常刺激，也能调动或增强听觉相关的奖励机制。确切来说，音乐并不一定要具有生物学意义上的适应性，也可以达到提高生活质量的目的。

Music is a universal feature of human societies, which suggests that an evolutionary perspective should help us understand our appreciation. The reward (pleasure) system of the brain offers a suitable framework. The question is why we evolved rewards for listening to and producing sounds with particular qualities. The primary evolutionary advantage is probably related to the importance of language; features of sound, such as purity, harmony, complexity, and rhythmicity, are useful for facilitating oral communication. One would expect evolution to associate rewards with these qualities in order to stimulate the development of brain regions involved in interpreting and producing relevant sounds. There are additional adaptive aspects of music, such as relaxation, social coherence, and sexual selection. Music can be regarded as a superstimulus that accentuates and exploits rewards associated with hearing.

**As such**, music is not necessarily adaptive in a biological sense, but serves the purpose of improving quality of life.

# Introduction（绪论）

大多数人都能轻易地将“音乐”与“其他声音”区别开来。音乐的使用普遍存在于人类活动中。正如在尚无精巧乐器的部落文明中，也会以吟唱或特殊的节奏创造音乐；史上第一件被发现的乐器是一支四万年余前的笛。进一步剖析“音乐欣赏”的内在因素会发现，它是一种显性于婴儿时期的自发属性，音乐也能与人类在精神意义上的共振。

Most people can easily distinguish music from other sounds; in fact, an interest in music appears to be a universal human feature [1,2]. Tribal cultures do not have advanced instruments but create music in the form of song and rhythm; the first instrument found, in the form of a flute, dates back some 40,000 years [3]. Further evidence, as to an innate component of musical appreciation, are, for one, that the capacity appears to arise spontaneously in infants [4]; and two, that music has a powerful effect on the human psyche [5,6].

鉴于该现象的先天程度，一种进化论的研究视角或许能解释我们对音乐的热情，以及试图厘清音乐能诱发我们大脑并引至实际行为的属性究竟何为。需说明的是，音乐也被用在各类社群的功能建设之中，就像某些非洲文明中，“击鼓”是成人礼的重要环节。而考察音乐特殊的社会地位云云更多与文化视角相关，而本文仅聚焦在生物学的解释或只能考察清楚音乐作为类原初属性的意义，而不能涉足其更广泛的文化意义。

（想在这里画个音乐指引大脑的图片）

To the extent that the phenomenon is innate, an evolutionary perspective should help explain why we care about music, and, possibly, suggest what features of music tingle our brain in a way that cause the engagement. However, music is also a social phenomenon that serves various functions in a community [7]. A biological explanation can only account for the inborn aspects; cultural traditions may be more important when examining the role of music in a particular society. For example, in several African cultures, drumming is an important component of rites of passage.

即将剖析我们对音乐的迷恋之际，让我们对人类大脑中奖惩机制引至行为的流程先有个大致理解。审美体验是一门有关产生类愉悦情绪的学问，涉及特定感官输入如何激发我们大脑的奖励机制。人有五感，任何形式的感官刺激都能触发奖惩机制，并以愉悦或悲楚之类的有正负色彩之分的情绪显现于表象。各研究中，对审美体验的考察一般意义上都基于听觉和视觉，至此，有关音乐的问题就在于：为何特定的听觉刺激能激活愉悦感，再进一步则是有关为何这种愉悦程度能水到渠成般地与人类个体创造力成正相关。

In order to understand our fascination with music, it is appropriate to consider the way human brains use rewards and punishment to guide behavior [8]. Aesthetic experiences are about how particular types of sensory input cause our brains to offer rewards in the form of enjoyment. Humans have a variety of senses, including vision, hearing, touch, and smell. Stimulation of any of our senses can activate rewards and punishment, in the form of pleasure and pain, where pain is used for any type of negative experience. Aesthetic experiences are primarily related to hearing and seeing. As to music, the question is why certain types of auditory stimuli are processed in a way that causes them to activate pleasure and, one may add, why this form of pleasure is so easily amenable to and enhanced by human creativity.

大脑接收的听觉输入是多样的。有平平无奇，不激起反应的；也有就像粉笔在黑板上的滋啦声，会带来不安情绪的；但也有相当类型的声音有带来愉悦感的潜质。

The brain receives a multitude of auditory input. Much of it is neutral, that is, it activates neither pleasure nor pain. Some of it is hideous, most people dislike the sound of chalk on a blackboard, but a considerable variety of sounds has the potential of inducing pleasure.

形成“听觉”只需简单的转化过程：耳膜记录下气压，而后转译为耳蜗中的神经元信号。就记录频率和信号转化强度而言，人类的耳朵并不是最灵敏的，但我们拥有最先进的声音神经处理能力——耳蜗中的信号会被听觉神经传送至丘脑，再到听觉皮层，其中可能发生最主要的处理和转译工作。将气压的微变转化为语言，还得识别声源方位、发音者，这可不是件简单事儿，大脑也需要随人类的发育不断提升这一能力来适配。

Sounds are simply variations in air pressure registered by the eardrum and translated to neuronal signals in the cochlea. Humans do not have the most sensitive ears, in terms of signal strength and frequencies registered, but we may have the most advanced neurological processing of sounds. Signals from the cochlea are sent by the auditory nerve to the thalamus and then passed on to the auditory cortex where the main part of the processing and interpretation presumably occurs. Translating minor variations in air pressure into language and recognizing not only where the sounds come from but who is speaking, are extraordinary tasks. It is to be expected that the brain needs to develop this capacity as we grow up.

哺乳动物都有听觉能力，而只有人类发展出了口语，喋喋不休。尽管音性在交流中的作用不容小觑，但就说话的目的来看，言语的内容会比声音本身更重要。接收或产生声音看来与至关生存问题没有太大直接关联，但人类仍愿意投入大量时力来精进这门技艺，而对此最直白的解释只是，这让人类感觉良好（至少在简单的进化角度来看，这是挺悖论的）。奖励机制旨在刺激适应性行为，但若交流中的话语会更对结果有适应性意义——那在交流行为中，音性究竟对激发奖励机制发挥着多大程度的作用？我会试着回答这个问题。

All mammals have a capacity to hear, but only humans have developed this faculty into oral language. Although music can play a role in communication, the spoken word seems to be superior for that purpose. Consequently, listening to or creating music seems unlikely to be directly important for survival; it is a paradox that people, nevertheless, devote so much time and energy to doing just that. The obvious explanation is that it makes them feel good. The reward system is meant to stimulate adaptive behavior, but if the spoken word is superior for the highly adaptive purpose of communication, why care about music? I shall suggest an answer to this question. The topic is partly covered in a previous book [9].

正如前文所说，音乐具有社交属性，研究中则需区分在不同情况下，真正激起奖励机制的，是声响带来的纯粹感受；还是某些基于音素产生的，蕴含奖励潜能的联想，就像情歌之所以动人，不仅是音乐本身，还因它指涉了“爱”的情感。本文重点是音乐的非交际性特征，关于人类文明中“美美与共”的部分。

As pointed out above, music has a communicative aspect, which means it is important to distinguish between the pure enjoyment of the sounds and possible rewards connected with the associations fostered. Love songs may, for example, stimulate some of the positive feelings involved in love. The present focus is on features of music that are not communicative. These features appear to be reasonably universally recognized and appreciated across human cultures [10].

# 2.Feelings Are Meant to Motivate Behavior（情感的行为指向性）

听音乐带来正向情绪，这意味着当我们的大脑能捕捉到声音中能激活奖励机制的那一些些微妙特征。为了更好理解这种倾向，我们得大概明白是大脑的什么能力为愉悦和挫败感的提供机制做支持。简单来说这也就是大脑在激励我们做出适当的行为决定。在此先简要解释一下下文将用到的大脑模型以及相关术语。（更详情的说明请参见[11]）

The positive experience when listening to music implies that the brain activates rewards when we hear sounds with the right quality. In order to understand why we have this propensity, it is important to first outline why the brain has the capacity to give us pleasure and pain. The short answer is that it motivates us to make appropriate behavioral decisions. The model of the brain I shall use, and the accompanying terminology, are briefly explained below. For a more detailed account, see [11].

感觉都有正负向之分。这些感觉再细分又可看到丰富的知觉：感觉经验能更进一步追溯到感官和情绪信号的发出。并且一种感觉的源头信号还可能也涵盖另一种感受经验，但这也通常和人际关系相关。

Feelings include any experience with a positive or negative connotation. They can be divided into sensations, which reflect pleasant or unpleasant experiences due to signals from our senses, and emotions, which include other forms of feelings, but are typically associated with interpersonal relations.

感觉（的评价）有两种类型：或好或坏（有关奖励机制或惩罚机制）因为感官旨在引导我们追求对基因更好的东西（如食物和伙伴），并规避有害的部分（如天敌和伤害），因而需要提示我们对此有所辨识。

Feelings are of two types, either good or bad (rewards or punishment), simply because they are meant to direct us respectively toward something that benefits the genes (e.g., food and mates) or away from anything that is detrimental (e.g., predators and injury).

当我们盘点人类大脑的功能时，“模块”或“功能”是很好的概念，有效简化理解。“模块”通常是在解剖意义上的分区（而非在神经功能上的），因此一个模块可能会涉及各种神经回路，也就可以理解，各种模块中，可能会重叠出现某些神经回路。

The concept of modules, or functions, is a convenient simplification when describing the inventory of the human brain. Modules consist of widespread nerve circuits but are often associated with certain anatomical regions. Various modules can use overlapping nerve circuitry.

无论积极还是消极,我们提到的经验（在此指感觉上的）通常都基于两大神经模块：负责处理感觉中积极或消极元素的情绪模块，和代表某一感觉“特征”的类型模块。例如甜味和听音乐都能激活情绪模块中的奖励机制，但其中的知觉经验是相当不同的。这种区分来自类型模块的伴随输入，并以不同模块的形式分别处理听觉和味觉，将这两者在大脑中认知中区分开。类似地，物理上的受伤能激起情绪模块中的“痛感”，但这又与被朋友背叛带来的心碎感不同。

Whether positive or negative, the experiences that we refer to as feelings are generally based on two overarching modules in the brain: The mood module is responsible for the positive or negative element of feelings, that is, the pleasure or pain, while type modules stand for the ‘characteristics’ of a feeling. For example, the taste of sugar and listening to music both activate the reward part of the mood module [12,13], but they are considered very different conscious experiences. The difference is due to the concomitant input from type modules, here in the form of the brain modules responsible for processing, respectively, taste and sounds. Similarly, a physical injury activates the pain part of the mood module, but so does being rejected by a friend [14].

情绪模块下属三个版块：其中两个生产积极情绪（通常被称作“追求（seeking）”和“喜爱（liking）”），并且这两者通常被统称为“奖励模块”（reward module）；另一个负责所有形式的痛感。情绪模块会建立一种“共同适配流通”的模式，让个体在情绪上保持动态平衡。例如吃蛋糕带来的快乐会抵消掉做了什么有害于身心健康的事情带来的消极感。

The mood module can be divided into three submodules: two that create positive feelings (typically referred to as seeking and liking), and one that cause all forms of pain [15,16]. The former two are here combined and referred to as the reward module. The mood module establishes a form of ‘common currency’ that allows the individual to balance advantages and disadvantages [17]. For example, the pleasure of taking another piece of cake is weighed against the negative feelings of doing something unhealthy.

情绪主要在于引导行为。不管是吃蛋糕也好还是听歌剧也好，就算翻来覆去地不断经历这同一种经验，只要某种经验会引起强烈的获得感，人们就愿意这么做。感觉通常都从大脑的无意识层面加工而来，所以人们大多情况下只是跟着这种感觉走，也不必刨根问底地知道其所以然。就跟我们常提到的“自由意志”一样：有意识地“深思熟虑”，根据个体自身水平能不同程度上影响或超越无意识层面去思考，但控制“要不要感受”也还是很难的（例如主动屏蔽一些烦心事，达到一种内心的和平）。

The point of feelings is to guide behavior. If an experience elicits a strong reward, whether it is eating a cake or listening to an opera, the person tries to obtain more of the same experience. Feelings are typically initiated by nonconscious processes in the brain, which means the individual can be compelled to follow their call without necessarily understanding why. Conscious deliberation, in the form of our level of free will, can to some extent impact on or overrule the nonconscious brain [18], but it is difficult to turn feelings on or off.

引发特定感觉的因素很大程度上是相对于个体的已有经验来讲的。意思是某一“特殊事件”能带来什么样的感觉主要取决于个人因素，也要考虑当时这些情绪是怎么被感知的临场情况。就像有人天然地享受刺激和惊险（例如爬山），有人也觉得这些是恼人的；而当某人愉快爬山的时候要是摔跤了，原本万物可爱的情绪很可能会陡然转为一颗阴雨连绵的心。

What triggers a particular feeling is to a large extent based on previous experiences. It means that a particular event can be either positive or negative depending on both personal factors and minute details in how the situation is perceived. Some people enjoy the thrill of a danger, such as climbing a mountain, while others consider the same task to be unpleasant. If the person who enjoys climbing slips and falls, the activity is likely to turn abruptly from positive to negative.

情绪中的或积极或消极的色彩也不都是显而易见的。就像哪怕完全没意识到某情形下有任何愉悦可言，但我们可能也会被一点点的满足感左右。更进一步说：我们或许会只是被奖励机制牵着鼻子走，甚至去做我们本不喜欢的事情，例如吸毒或其他的强迫行为。

The positive and negative aspects of a feeling are not necessarily obvious. We can be swayed by ‘drops’ of satisfaction without being consciously aware that there is any pleasure involved [19]. Moreover, we may follow the call of the reward module even when we dislike where it takes us, as exemplified by drug addicts and other forms of compulsory behavior.

很可能在三亿年前，第一代羊膜生物体内就已进化出能体会感知的情绪模块了。若关注其功能性，作为一种生物体内引导行为的策略，情感或许在当今工业社会中并不具有必然的适应性。人类的大脑成型于一个生存环境与当今完全不同的时期，因此我们也因根据实际情况具体分析。就像滥用毒品或暴饮暴食吃垃圾食品之类的疑难行为案例在当下屡见不鲜，也与当前环境中能提供的可能性有关。若相同的可能性在我们早先发育尚不成熟时就出现了，那么进化中机体可能就会执行一些策略来避免这类行为。

The evolution of the mood module, and thus feelings, probably started more than 300 million years ago with the appearance of the first amniotes [20]. As a strategy for directing behavior, feelings are not necessarily adaptive in present, industrialized society. The human brain was shaped at a time when the conditions of living where considerably different; abuse of narcotics, or binging on unhealthy food, are common examples of dubious behavior due to opportunities in the present environment. If the same opportunities had been easily available in our distant past, evolution would presumably have installed a strategy to avoid this sort of behavior.

该章节观点可概述为：奖励驱动的行为并不总是服务于适应性目的。例如在当下存在避孕药的前提下，人类享受性行为并不以传播基因为目的。同样，创造具有审美价值的音乐和花时间听音乐激活大脑中奖励机制，但也就并不一定意味着这些行为具有任何进化优势。那么音乐究竟为何能带来回报？下面我们将来讨论其中种种因素。

The point of the above paragraph can be generalized by stating that reward-driven behavior not always serve an adaptive purpose. For example, people enjoy sex in the presence of contraceptives even though the activity does not propagate the genes. Likewise, creating sounds with aesthetic value and spending time listening to music do not necessarily imply any evolutionary advantage, but may reflect the activation of rewards in the brain. Below, I shall discuss various factors that help explain why music elicits rewards.

# 3. The Aesthetic Elements of Music（音乐中的美学元素）

## 3.1. The Language Connection（能指连接）

我们的大脑为何会乐此不疲地倾向于以激活奖励模块的方式来处理某些特定的音乐刺激？音乐中，声音中能带来特殊刺激的属性统称为“审美元素”。在这一概念内中的系列元素理论上是普适的，也因此对这些元素的讨论并不仅限于对某一特殊个体或文化的考察，而是或许能反映人类更普遍意义上与生俱来的倾向。并且这种刺激能激活奖励机制——也说明在过去的某时段中，人类在生存中出于某些原因需要迎合声音的这些方面。可以推测声音的这些方面对引导进化中某种适应性优势的出现有相当重要的作用。

In order to understand music, it is important to describe why the brain tends to process certain forms of auditory stimuli in a way that causes the activation of the reward module. The particular quality of sounds required are referred to as aesthetic elements. The list of elements should be restricted to those that are reasonably universal, and thus likely to reflect innate tendencies, rather than those that apply only to certain individuals or certain cultures. The activation of the reward module suggests that catering to these aspects of sounds offered an adaptive advantage at some point in our evolutionary past.

在动物中，听力最主要的两个功能是：一、警惕有潜在危险的个体；二、与同类交谈。人类在进化中对后者有相当程度的扩展。语言对人类来说有相当重要的适应性价值，这也说明在我们享受音乐的能力演进中，语言发挥了关键作用。始于达尔文的《人類的由來（The Descent of Man）》，一些作者已证实了音乐和言语的关联性。最新研究回顾详情请见[22]。

In animals, the capacity to hear serve several functions, the two most common are: one, to alert the individual in case of danger; and two, to communicate with members of the same species. Evolution expanded the latter function to an extreme degree in humans. For us, language has considerable adaptive value, which suggests that language played a pivotal role in the evolution of our capacity to enjoy music. Several authors, starting with Darwin in his book The Descent of Man [21], have proposed a connection between music and language; for a recent review, see [22].

智人并非唯一用声音交流的种族，但对典型的哺乳动物来说，嗅觉会更多地成为信息素传递的途径。但嗅觉信号不适合长时间都栖息在水中或空中的动物，就像鲸、蝙蝠还有鸟之类的动物。这些动物也就进化出了更高级的口头交流形式。人类作为陆生动物，这一点不能直接挪用上述图景作解释，但我们也确实进化出了极其发达、甚至远超其他动物的大脑，它能够及时处理信息交换中每个细节。嗅觉中的复杂信息很难提取并清晰转化，但听觉信号可以。因而在此方面，增强转译和提升声音质量的能力对我们来说相当需要。

Homo sapiens is not the only species that communicates by sounds, but for typical mammals, smell in the form of pheromones is more important. Olfactory signals are not suitable for animals that spend most of their time in water or in the air. These animals, including cetaceans (whales), bats, and birds, have evolved superior forms of oral communication. Humans live on the ground, so we do not fit directly into this picture, but we did evolve a particularly advanced brain that allowed for a fine-tuning of information exchange far beyond that of any other animals. It is difficult to turn smell into complex information, but auditory signals can. What is needed is an expanded capacity to interpret and create sounds of the right quality.

在转译听觉信号和使用最发达的发声器官（属于工具模块，译者注）方面，人类可以说是拥有功能最强大的大脑。每次言语的生成通常都涉及每秒超过两百次肌肉运动的协作。这些特征大概是伴随我们口头交流的能力进化而来的。不过，这种能力本身也需要大脑的再进化；语言的极其复杂性也意味着它没办法被预先充分给出，所以这是个体必须在出生后逐渐发展的能力。 “游戏”是进化最典型的方式，个体可以在此过程中获得必要的能力训练。

Humans arguably have the best brain when it comes to interpreting auditory signals and the most advanced vocal apparatus. The production of speech typically involves the coordination of more than two hundred muscle movements every second [23]. These features presumably evolved concomitantly with our capacity for oral communication. However, this capacity also required an additional change in the brain; the extreme complexity of language means it cannot be entirely preprogrammed, the individual must gradually develop the competence after birth. Evolution typically uses what we refer to as play behavior to make sure the individual takes part in the necessary training.

游戏行为旨在帮助个体发展出在今后生活中所需的技能。例如为提升肌肉协调性，而去做能提升其所需的神经回路的游戏。游戏活动对基因本身相当重要，奖励机制也就往往伴随进行，以确保个体的参与度。在游戏中，转译声音和把握并使用声音的能力都会得到充分锻炼。为促进实践，无论是有关说的还是听的，大脑在此过程中都会随之释放奖励机制。简而言之，强化我们天生的语言板块是需要练习的，音乐对此似乎是相当适配的形式。已有研究发现，儿童在接受音乐培养时也会提升他们的阅读能力和对单词的记忆力。

Play behavior is meant to help the individual develop skills required later in life; for example, in the form of improving the nerve circuitry required for muscle coordination. As play is an important activity for the genes, it is coupled with rewards in order to ensure participation. Children enjoy their play. Both the capacity to interpret sounds and to use the voice require extensive practice. The brain presumably offers concomitant rewards for this practice, whether in the form of babbling or listening. In short, exercise is required in order to develop our innate template for language [24], and music appears to be a suitable form of sound for this endeavor. It has, for example, been shown that children who receive musical training improve their reading skills [25] and are better at remembering words [26].

但在此还要谨慎说明：要是我们所谓的“音乐快感”其实是源于对听觉训练或声乐能力提升的需要，那“音乐”究竟是个什么角儿？若取掉对声音类型的特定选择，要说行为偏好，口头言语或许会更有实际意义。而且当前提到的有关游戏行为的考察大多着眼于“儿童”阶段，对音乐的兴趣理应会随着进入青春期而下降。而事实是就算主要负责语言神经回路基本成型，大脑也仍保持着对声音的专注探索。原因之一是语言本身的复杂性和持续的更新，这要求成人也要不断加强对信息的转译能力和整合口头表达的能力；其二在于人类需要利用感官进行探索行为，听觉在其中有其自身的特殊地位。从环境中获取信息对于成年人来说更为重要，因为他们负责安全和寻找食物。

There are some caveats to this idea. If our joy of music is due to the need to exercise our auditory and vocal capacity, why music? One might argue that any sound would do, and that if there is a preference, spoken words would be the obvious choice. Moreover, play behavior is primarily associated with children, so the interest in music should decline along with puberty.

As to the latter point, even when the main circuitry required for language has been established, the mind still needs to sounds. For one, the complexity of oral language suggests that adults as well are required to exercise their interpreting and sound-producing capacities; and two, humans use the senses, hearing in particular, for exploratory behavior. Exploratory behavior is also associated with brain rewards, and it implies taking an interest in sounds. Obtaining information from the environment is even more important for adults, as they are responsible for safety and for finding food.

至此看来，音乐能带来的极致共感力不是仅靠游戏或探索行为就能解释的。我想，“享受音乐”的能力究竟何为，游戏和探索的奖励机制只是它的起点，尚不足以给出具针对性的解释。我将首先讨论音乐的特征（这里称为审美元素），这些特征使其适合于口头交流的实践，并能解释我们为何对音乐有着超出言语之外的迷恋。接下来，置与交流直接相关的部分于一旁，我将考虑音乐中或许能解释奖励机制如何活跃的其他因素。

Considering the awesome emotional power of music, can it really be explained solely by play or exploratory behavior? I believe the rewards associated with play and exploration are likely to have been the starting point for our present capacity to enjoy music, but that they do not offer a complete answer. I shall first discuss features, here referred to as aesthetic elements, of music that makes it suitable in connection with the practice of oral communication. These features suggest why we have a fascination for music rather than focusing solely on spoken words. Subsequently, I shall consider other factors that are not directly connected with communication but are likely to help explain why the rewards are so powerful.

## 3.2. Sequential Information（乐理序列）

黑猩猩能发出约三十多种叫声，而我们与他们的口头交流的关键区别在于，对他们来说，每种声音都有特定的含义。他们能通过控制音量和重复的手段来附加信息，但这不成语法。而人类的语言基于单词和短语，将声音按特定方式组合形成含义，单音通常没有意义。这种按序列的信息组成，或说是有时间线的构成模式在音乐中也很重要。为能达到“欣赏”的效果，一段旋律需要考虑使用各种与乐理相关的音律组合，就像和声和音阶之类的。

Chimpanzees produce perhaps thirty or more calls with distinct meaning [27]. A key difference between their and our oral communication is that, for them, each sound has a particular connotation. Additional information can be extracted from loudness and repetition, but they do not form syntax. For humans, a single sound is typically without meaning, we need to combine sounds sequentially to produce content—language is based on words and sentences. Sequential information, or temporal patterning, is also important in music. In order to be appreciated, a melody needs a variety of tones tied together by principles such as harmony and scale.

## 3.3. Complexity, Coherence, and Fluency（复杂性、连贯性和流畅性）

和人类的“音乐”相比，鸟儿悦耳的鸣叫缺少某种特质。它们的鸣叫有规律地持续重复，甚至下一段频率都是可预测的；而我们的发声更复杂。如上文所述，为了能处理更细致的内容，语言需要复杂。闹铃声或任何基于某（几）段频率的声音都没那么有趣，也因此就算音频都不断重复，我们并不能从每段中都获得等值的“奖励”。人类的探索要求声音具有一定程度的复杂性（才能传递精确的信息），来刺激我们的探索欲。但就像混乱的噪音，声音变得过于复杂，反而也不会提供什么可解读的信息。在能达到“分析”前，大概也先需要声音信息的各方面是有机组合在一起，能为人接受的，这以**某种特定程度**的连贯性为原则。“连贯”的概念也与视觉艺术中的“流畅性”观念互通。具有较高流畅度的视觉或听觉事物更易于大脑处理，获取信息。就一段流畅的音频来说，听者自然而然就能感到各要素紧密相连，组合在一起成为整体。

Bird song may be pleasing but it lacks certain qualities compared to human song or music. It appears to be stereotypic, predictive, and repetitive; we cherish more complexity [28]. As pointed out above, language requires complexity in order to convey detailed content. An alarm clock, or any sound based on one or a few frequencies, is not interesting and thus not equally rewarding. A measure of intricacy is needed for human exploration, the sounds need to stimulate our curiosity. If the sound becomes too complex, like scrambled noise, it does not offer any feature that allows for interpretation. We presumably prefer some level of coherence in the form of principles that connect the various facets of the sounds and thus offer a substrate for analysis. The idea of coherence is related to the concept of fluency in visual aesthetics [29]. A high fluency implies that the visual or auditory object is easy to process; in the case of sounds, the listener automatically senses that the components are tied together and form an entity.

音乐中突如其来的“惊喜”或许会是引起不适的惊吓，但对于恐惧阈值较高且事实上处在安全环境中的人来说，这也会激发好奇心。我们喜欢探索更新颖的刺激形式，但在我们的倾向中也有一定程度的“熟悉感”。音乐就常会在可接受的期待范围内带来一连串有趣的惊喜。

A sudden surprise in music may be felt as an unpleasant startle, but for a person in a safe setting and not prone to fear, it is more likely to stimulate curiosity. We like to investigate novel forms of stimuli but prefer a certain level of familiarity. Music typically offers a series of interesting surprises set against a background of expectation.

## 3.4. Purity and Harmony（纯度与和谐度）

音符的纯度（即某段音乐有特定的音高或频率，不至于产生噪音的品质）是音乐的关键特质。就像当我们谈及各音素间的协和与整体的和谐度，也是在讨论关于不同频率间的特殊关系。对纯度和和谐的偏好也是天生的。这些品质受到青睐（这意味着听或制作有这类品质的音乐本身时，大脑会提供一定的奖励）的原因之一可能是它们可以增强口头交流。

Purity of notes, that is, using a particular pitch or frequency as opposed to scrambled noise, is a key feature of music. The same is consonance and harmony, which imply that the different frequencies stand in a particular relationship to each other. A preference for purity and harmony appears to be innate [4]. One reason why these qualities are favored, which means they offer drops of rewards when heard or produced, may be that they enhance oral communication.

动物中主要以声音信号作为交流的主要方式的（像鸟、鲸之类的），拥有产生纯度较高声音的能力。纯净的声音不那么模糊，也能传得更远。多种声音的有机协和能继而减少话语歧义。与混乱的声音相比，一段清晰的、不同频率有序排列的声音信息会更容易被理解。

The ability to produce pure sounds is found in animals where auditory signals are the main form of communication, a list that includes most birds and whales [30]. Pure sounds presumably are less ambiguous and travel further. Consonance reduces ambiguity. It is easier to interpret a message with distinct frequencies compared to more random sounds.

语词是一个相对纯净的音（元音）和不那么和谐的音（辅音）构成的整体。在某语言中，若特殊音节的涵义也要随声调变化而定，那么这类语言被称为声调语言（tone languages），例如汉语。相比非音调语言者，汉语言者似乎会对声调的各种变化更敏锐。也许人类最早的语言也主要依托音调和纯度这两个特性，也就是说，它的形态可能更像是我们当前概念中的“歌”。

Language consists of a mixture of relatively pure (vowels) and dissonant (the alphabetic consonants) sounds. In certain languages, the meaning of a particular syllable depends on the pitch; these are referred to as tone languages and include Chinese. Chinese speakers seem to be better at hearing variations in pitch compared to those who learn non-tonal languages [31]. Perhaps the first human languages depended to a larger extent on both pitch and purity of sounds; that is, they were more like what we refer to as song [32,33].

难道我们歌唱比我们言说还要早？这是有据可依的：尤其就像鸟或者鲸的口头交流，在我们看来就是一种歌声。而且若真是如此，“以歌表意”到“语言沟通”的过程也是可解释的：言语比歌声更细节，能够适应更加复杂的沟通需求。更复杂的构成也需要更多的不和谐音（辅音）。简单来说，交流的功能由音乐移交给口语是由于我们智力的提升，也能顺应随之而来的对更准确的语言沟通能力的需要。显然，在当下奖励机制也仍然宠幸纯净度和他的兄弟和谐度。也可以说，我们“以歌表意”的进化阶段遗迹仍能（部分地）从一些“非理性可解读”的形式（就像音乐一样）中被窥见一隅。很有趣，你会发现幼儿也是先掌握元音，而后需要更多时间来掌握辅音；我们的一些猿类亲戚，长臂猿和合趾猴之类的，已经进化出了唱歌的能力，他们和鸟一样生活在丛林中，嗅觉不太适合作为沟通的发展方向。

Did we sing before we could talk? The idea makes sense, not the least because the oral communication of birds and whales is referred to as song. Moreover, a plausible explanation for why we stopped singing and started talking lies in the increased need for complexity for the sake of communicative detail. Complexity was achieved by including more dissonant sounds (the consonants). In short, communication moved from song to the spoken word because of our enhanced intellect and the concomitant need to increase the capacity to accurate communication. Apparently, the reward system still favors purity and its cousin harmony; in other words, the song stage may have left relics in the form of a (partly) ‘irrational’ like for music. It is interesting to note that children first manage the vowels, but need more time to master the consonants [34]. Some of our ape relatives, the gibbons and siamangs, have evolved the capacity to sing [35]. These apes live in the canopy where, as in the case of birds, olfactory communication is less suitable.

## 3.5. Rhythm（节奏）

在我们谈音乐时，大多情况都绕不过“节奏”这一典质。节奏乐器制作更简单（一根棍儿还有一些能敲棍儿的东西就够了）。在部落文化中，节奏乐器比管弦乐器更常见，特别是在舞蹈要随歌而起的情况下，节奏的核心地位显而易见。

Rhythm is a characteristic feature of most music. Rhythm instruments are easier to make (a stick and something to hit the stick against suffice); thus, in tribal cultures, they are more common than wind or string instruments. Here, the core function of rhythm is obvious, not the least because the music is often combined with dancing.

即使到现代，节奏也是音乐欣赏的重要因素。节拍有很多功能：它提供了一套声音的有序组织；它本身也有一种“安抚”效果，危险的声音往往毫无节奏，不可把握；也或许因为节奏类似于胎儿在子宫中能听见母亲心脏有规律的脉搏；节奏与各物种的不同行为特征相关（译者注：通过节奏差异我们能辨识周围的生物信息）。

Even modern music tends to require rhythm in order to be appreciated. The beat may serve several functions: It offers a way to sequentially organize the sound. It is also likely to be a comforting feature, because dangerous sounds do not tend to be rhythmic, and perhaps because it resembles the pulse of the mother’s heart as registered in the uterus [36]. Finally, rhythm is a feature associated with several aspects of behavior in various species [37].

## 3.6. Emotions and the Human Touch（情感与人性）

音乐中有独特的表意形式（就像情歌），即使是最简单的器乐也能表达创作者的情绪或是其他品质。人类的社会性本质意味着我们会对同类感到好奇，这也意味着当我们在体悟到人性时，大脑会释放奖励。当一个人发出声音，我们会不自觉地去探索暗藏其中有关他/她情感生活的蛛丝马迹。只要是“人类的声音”，就可以无论形式地提供此类信息，不管是言说还是歌唱，音乐家手中的乐器也是如此。事实上，人类就“特定有序的音乐组合会反映什么情绪”，有种心照不宣的一致倾向。

Music can include a distinct communicative element, for instance, in the form of a love song, but even purely instrumental music can reflect mood or other qualities of the person(s) producing it. Our social nature implies that we are curious about fellow human beings, which means we are rewarded for deciphering a human touch. When a person creates sounds, we tend to search for clues about his or her emotional life. A voice offers this sort of information, whether it is speaking or singing, and so does an instrument in the hands of a musician. In fact, people tend to agree on what emotions a given sequence of music reflects [38].

情绪色彩是能直接感染人的部分，就像有的音乐写来就是为了让听众体会欢欣鼓舞氛围的。若旋律色彩恰到好处地跟随了演奏者的某种与该语境相似的情绪，就会达成理想效果。这种情况下，只要能激活奖励模块，就算“悲伤”也可以产生积极效果。例如，在人们阐释“忧伤”经历时，有的人会将其视作一种积极经历；在一些实验中，研究人员对叙述中报告者的大脑活跃部分的分析也证明了这一点。伤感音乐能带来积极体验这一事实能部分说明，我们的同理心和同情心能激活奖励。

The emotional content can be directly appealing, such as music designed for the listener to feel joy and elation. This effect is achieved if the melody appears to be due to similar emotions in the performer [39]. In this context, it is relevant to point out that even sadness can have a positive connotation, which here implies activation of the reward module. For example, grief can be regarded as either a negative or a positive experience; the point is not only apparent in how people describe what they go through, but can be seen when analyzing the parts of the brain active while reporting grief [40]. The positive experience of sad music may partly reflect that we are rewarded for empathy and compassion [41].

与表演者的连接感意味着音乐也能带来“陪伴”——某种意义上就跟宠物一样。它能减轻我们的孤独感，并激活与社会性有关的奖励。这一点或许能解释为什么当今西方社会语境下，音乐在缺乏却又渴望陪伴的年轻人中如此流行。

The sense of connecting with the performer implies that music can also serve as a ‘companion’—somewhat like a pet. That is, it reduces loneliness and offers rewards related to socializing [42]. The point may help explain why music is so popular among the young of companion-starved Western societies.

## 3.7. Relaxation（放松）

不止是人类会用音乐放松，动物也一样。节奏和音乐本身的平缓与连续性或许与此相关。

Music can have a relaxing effect not only on humans, but on animals as well [43]. Both rhythm and the fact that music tends to be smooth and continuous may help explain this observation.

一首曲子或许包含壮阔且富于变化的音乐给观众带来迷人体验，但这种音乐通常不是用来让农夫抚慰他的奶牛，或者在商场里制造一种轻松愉悦环境的。在自然环境中，突如其来又意料之外的声音通常都意味着危险；而无论是音乐还是汩汩流水，平滑流畅的声音属于平静的环境，被判断为“安全”的声音能放松大脑。例如用来安抚婴儿的摇篮曲可能是在跨文化语境中都最通行的音乐形式，它缓慢、轻柔、反复如低喃，让儿童感到亲切。

A composer may include strong and abrupt sounds for captivating an audience, but this music is typically not used by the farmer who wants to calm his cows, or by the supermarket where the point is to create a relaxed and positive atmosphere. In a natural environment, sudden unexpected sounds typically imply danger; smooth and continuous sounds, whether in the form of music or the flow of a river, suggest peaceful conditions. Sounds that are deemed safe relax the brain. Lullabies are, for example, meant to calm the infant. They are perhaps the most universally recognized form of music cross-culturally, and are typically slow, soft, repetitive, and familiar for the child [2].

## 3.8. The Chills（“不寒而栗”）

上面提到的美学因素也许能解释对音乐各方面的鉴赏，但情感回馈往往比人们基于奖励伴随的预期所能想象到的更强烈。“寒意”（chills）作为一种强烈愉悦体验正是一个典例。寒意或惊颤（thrills）就是一种特别强烈的情感反应，像是脊椎发抖或起鸡皮疙瘩的感觉。

The aesthetic elements suggested above may explain an appreciation for music, but the emotional response can be more overwhelming than what one would expect based on the anticipated strength of accompanying rewards. The intense pleasurable experience described as the chills is a classic example. Chills (or thrills) are a particularly strong emotional response felt as a shiver down the spine or a gooseflesh type of skin sensation [44].

人们希望进化是能限制在适应性行为范围内的。过分专注于音乐的人处理其他任务或避免危险的能力会弱一些。如果你完全被一首歌迷住，你可能会掉以轻心，忽视掠食者。也就是说，与音乐相关的奖励并不会是把我们的注意力转移到非适应性的程度上去。“寒意”似乎可以说是过度分散了注意力。

One would expect evolution to restrict behavior to what is adaptive. A person who is preoccupied with music has less capacity to cater to other tasks or to avoid dangers. If you are totally mesmerized by a song, you may fail to detect a predator. That is, the rewards associated with music should not divert our attention to an extent that is nonadaptive. The chills appear to be excessive distraction.

让我们试图分析会使音乐产生“寒意”的品质：忧伤比欢快的音乐更易引起寒意；熟悉的音乐比新奇的曲调更易产生这种感觉；激烈的段落（例如渐强）特别容易激起寒意；此外，女性比男性更容易体验这种感觉。或许这种种因素能让声音直接进入到大脑情感回路中的某一方面。这就像婴儿为呼唤母亲而发出的哭喊声。婴儿的求救指向了一种引起父母、尤其是母亲强烈反应的期望。这种哭喊声具有“产生令人发颤”的特性：激烈、亲近，而又悲伤。当我们的祖先进化出语言能力前，为确保父母能尽到抚养义务，我们的基因或许就已经设计好大脑中相应的奖励机制。寒意或许正反映着这一奖励系统的激活。

The qualities of music that tend to produce chills point toward an explanation [44,45]. Chills are induced more often by sad than by happy music, by familiar music rather than novel tunes. Intense passages, such as crescendos, are particularly likely to induce chills. Furthermore, they are more commonly experienced by women than by men. It may be that these factors cause the sound to hook directly into one facet of the brain’s emotional circuits; that is, they mimic the call of an infant crying for the mother. A baby’s call for help is expected to produce a powerful reaction in parents and particularly so in mothers.

The cries have properties related to chill-producing sounds: they are intense, familiar, and sad. Long before humans evolved the capacity for language, the genes had presumably designed the brain to offer rewards to ensure that parents would attend to their children. The chills may reflect an activation of this reward system.

正如爬行动物前肢向翅膀的进化演变，寒意或许也意味着进化会倾向发挥现已有结构优势，达到新目的。随着口语的日益更加重要和复杂化，进化要求以奖励机制的形式提供强有力的激励，来确保我们会投资精力来学习和掌握某种生活能力。从父母对自己孩子关注的情感奖励中吸取经验来达到相似的效果，也正是用来保证这种兴趣的办法之一。

It is also possible that the chills signify the way evolution tends to utilize structures already present for novel purposes, as exemplified by the way wings evolved from the forelimbs of reptiles. As oral communication became more important and complex, evolution needed to install potent encouragement, in the form of rewards, to make sure we would invest in learning to master this aspect of life. One way of ensuring interest would be to recruit the emotional rewards associated with parents’ attention to their babies.

# 4. Sexual and Social Selection（性与社会选择）

还有一些会增强有关音乐的奖励机制的因素。例如，有说法是音乐天分会是伴侣选择的考察依据之一——“性选择”也为音乐鉴赏能力的进化做出了贡献。我们观察到动物发出的声音中大部分都是求偶的叫声。至少在某些动物中，叫声呈现出的复杂性很可能是也是性选择进化的结果，因为它们倾向选择更“巧舌如簧”的对象做伴侣。这种性选择思路在人类中也大抵相同，就像我们能观察到“爱”是歌曲创作老生常谈的话题。

There are additional factors that may have amplified the rewards of music. For example, it has been suggested that mate choice depended on musical aptitude, which means that sexual selection contributed to the evolution of music appreciation [22]. In animals, a large share of the vocalizations observed are courtship calls. The complexity of the calls are, at least in some species, likely a consequence of sexual selection; that is, the partner preferred those with the more advanced ability to vocalize. The idea of similar sexual selection in humans is congruent with the observation that love seems to be the most popular topic for songs.

但我们需要注意的是：性选择确实对于我们音乐的偏好有促进作用，但前文所分析的那些因素才是更根本的，性选择会强化某些特征，纳入我们讨论的考量之中，但其并不产生原初性作用。

Although sexual selection may very well have expanded our propensity and delight in music, elements such as those discussed above most likely came first. Sexual selection tends to accentuate certain features, but not to generate features from scratch.

对社会关系的把握以及社会凝聚力是我们考虑到的另一可能的因素。音乐在社会中的作用是有目共睹的：无论宗教仪式还是世俗性的聚会，从金色大厅到篝火晚会，音乐都有参与其中。音乐性的活动或经典歌曲往往构成一种集体记忆。现在就有一门的学科叫音乐民族学，考察音乐的社会文化语境。现实情况也可能增强我们对音乐的掌控力和偏好度。不过，至少在我看来，这些因素不大可能会属于我们音乐欣赏进化的源动力。

Selection for social bonding or social cohesion is another possible factor [46]. There is no doubt that music can serve a role in society: it is commonly involved in both religious or secular social gatherings. Music and song are collective experiences, whether around the campfire or in a concert hall. The study of the sociocultural context of music has been referred to as ethnomusicology [47]. Again, the social factor is likely to have enhanced our capacity and pleasure in music, but is, in my mind, less likely to be the factor initiating the evolution of our appreciation.

# 5. Conclusions—For the Service of Life Quality（结论——为生活服务）

狗依赖敏锐的嗅觉，它们可能对演唱会和画展啥的就不太感兴趣了，但我猜他们会喜欢一家有奇奇怪怪味道的“画廊”。与狗相异，我们的导源是音频和视觉信号，接受嗅觉信号没那么灵敏，这也是生物选择，在人类的生存活动中，更多会用到视听觉来做判断。我们的愉悦神经与生俱来地为音乐留出余地，音乐能以最大充能带来极致享受。单个审美元素带来的奖励可能就跟一滴水一样，小得我们的神经都无法察觉，更别提将其判作“快乐”，而就算是个别呈现，元素间的相关性也是有限的。因而可以说分析一次欣赏行为时，也涉及多种美学元素及其组合的问题。换个说法就是“音乐旨在通过将各种听觉刺激结合起来，并产生协同效应，从而利用各种听觉刺激的潜在的奖励。”讲明这些，这有助于我们在实操中功能性地运用“音乐”，就像将其用作例如紧张、焦虑甚至痴呆等各种病理性症状的治疗工具。

Dogs depend on a keen sense of smell. They are unlikely to delight in a concert, or an art exhibition, but I am sure they appreciate a ‘gallery’ with interesting odors. Compared to dogs, we are expected to derive more pleasure from auditory and visual signals, and less from olfactory signals, simply because the auditory and visual signals are more important for human survival. Music is designed to hit pleasure circuits in the brain with maximum power.

The rewards elicited by individual aesthetic elements may be in the form of ‘drops’ too small to be recognized as pleasure. The appreciation presumably depends on the combination of several aesthetic elements that have limited relevance if presented in isolation. Another way of describing this is to say that music is designed to take advantage of the reward potential of various auditory stimuli by combining them to yield a synergistic effect. The potent effect of music is reflected in the observation that it is used as a therapeutic tool for conditions ranging from stress and anxiety to dementia [6,48].

诸如社会和性选择的因素可能促进了人类之于音乐愉悦性的进化。以各形式显现的文化条件（例如经济激励措施、地位，或审查制度和供销制度），也会影响实际的音乐生产与消费的兴衰。在西方社会，文化倾向于促进对音乐的关注。

Factors such as social and sexual selection likely enhanced the evolution of human delight in music. Cultural conditions can either promote or subdue the actual production and consumption of music in a society, for example, in the form of economic incentives, status, censorship, and availability. In Western societies, the culture tends to promote a preoccupation with music.

据相关研究证实，音乐对相关奖励模块具有成瘾性。听音乐对一些人来说，就像是对某种成瘾物质的适应不良行为。例如他们明知道音量过分嘈杂会影响听力，或者不加节制地沉浸在音乐中会妨碍更重要任务的执行（却还是这么做）。

The reward model of music is supported by the observation that music can take on an addictive character [49]. For some people, listening to music is reminiscent of the maladaptive behavior associated with addictive substances; for example, they knowingly insist on playing music so loud that it results in a loss of hearing, or so often that it prevents the execution of more important tasks.

若释放愉悦感的刺激又十分易获，则往往就会引发过度消费。在当今，音乐资源一应俱全，但要说在“成瘾物”中，音乐也倒是最好的选择了，毕竟是比毒品和垃圾食品对健康的危害要小。

Stimuli that release agreeable sensations tend to initiate excessive consumption if they are easily accessible; in present societies, music is **readily available**. As an addictive substance, however, music is about as good as they get. It certainly is less hazardous than drugs and unhealthy food.

虽然正文中提到的美学元素与动物性相关，比如镇静效果，人类也还是唯一能真正“欣赏”音乐的物种。鸟类歌唱，甚至可能也会为练习自己的发声能力或新增对所听内容的理解而获得奖励，但他们的口头交流似乎仍主要基于一套预编程系统。

Although some of the aesthetic elements suggested above may be relevant for animals, such as the calming effect [50], humans are likely to be the only species that really appreciate music. Birds sing and may very well be rewarded both for practicing their own vocal capacity and for learning to interpret what they hear; yet their oral communication appears to be largely based on preprogrammed systems [51].

音乐在当今社会的作用不一定是生物性的，但这也并不表明他就完全不是。生命的目的不是最大化生育，将其定义为“提高生活质量”或许更加合理——音乐能很好地与这条道路相契。

The role of music in present society is not necessarily adaptive in a biological sense, but there is no reason why it should be. It seems more sensible to define the purpose of life as improving life quality [8], rather than maximizing procreation, and music serves this purpose well.