The Human Brain on Music #1

Why do we find ______ ____ in music? Interestingly, there is ____ _____ of the brain that is ___________ ______________ and exclusively to music. Music is like a ___________ ________ for the brain. Musical activity involves _______ ______ _______ of the brain that we know about. For example, a pianist is an ____________ _______, a physically skilled athlete, and an individual with ____________ _______ and information-processing all at the same time. Their incredible performance is enabled by the highly ________ __________ _____________ of different parts of the brain. However, music is ____ _____ ____ experts. Our brain shows incredible performance even when we _____ _______ ____ music. Most of us become _______ ___________ by age 6 and are able to form _____________ ______________ and understanding of music. The fact that you can listen to and find joy in music is actually ___________ ____ intricate functions of the brain, some of which are _______ ____ language processing. Understanding why we like music and what ______ ____ ____ it is a window into the ________ ____ ______ _______. What functions of the brain enable our ability to ______ ______?

Why do we find great joy in music? Interestingly, there is no area of the brain that is dedicated specifically and exclusively to music. Music is like a full-body workout for the brain. Musical activity involves nearly every region of the brain that we know about. For example, a pianist is an expressive artist, a physically skilled athlete, and an individual with remarkable memory and information-processing all at the same time. Their incredible performance is enabled by the highly complex parallel interaction of different parts of the brain. However, music is not only for experts. Our brain shows incredible performance even when we just listen to music. Most of us become expert listeners by age 6 and are able to form appropriate expectations and understanding of music. The fact that you can listen to and find joy in music is actually supported by intricate functions of the brain, some of which are common to language processing. Understanding why we like music and what draws us to it is a window into the essence of human nature. What functions of the brain enable our ability to enjoy music?

dedicate	専用に充てる	enable	可能にする
exclusively	排他的に、専ら	parallel	並行した
expressive	表現力豊かな	interaction	相互作用
athlete	アスリート、運動選手	expectation	予測、期待
remarkable	卓越した、著しい	intricate	複雑な、精巧な
information-processing	情報処理の	essence	本質

The Human Brain on Music #2

When we enjoy listening to music, what is happening in the brain? Put simply, the brain ________ __________ _____ an _____________ ______ ____ ______ in its prediction. When we listen to music, the brain predicts how it will _______, and emotion arises when these expectations are ____ ____. The pleasure of music depends on how well it strikes an ________ ________ between aligning with listeners' expectations and __________ ___________ them. According to a theory proposed by British neuroscientist Karl Friston, the purpose of the animal brain is to constantly __________ ____ __________ ______ and behavior so as to __________ ____________ ______ in sensory input. The brain does not perceive the world passively, but rather _____________ __________ the surroundings based on its internal model. For example, when we observe a ball falling toward the ground, the brain predicts how it will fall and bounce ______ ____ ______ ____________. When predictions fail, the brain experiences surprise, and then ________ ____ __________ ______ to minimize the surprise. The brain experiences pleasure as it effectively __________ its internal model. In other words, prediction error and the ____________ __________ of the internal model imply that __________ ______ ______, leading to a more ________ ______________ of the world. Too little prediction error means a _____ ____ __________, so the brain finds it boring. On the other hand, too much error implies that the existing internal model is significantly wrong, which causes ____________ ____ ________. Music that partly meets the listener's expectations yet introduces a __________ _______ ____ ___________ provides the brain with an optimal level of prediction error.

When we enjoy listening to music, what is happening in the brain? Put simply, the brain derives pleasure from an appropriate level of error in its prediction. When we listen to music, the brain predicts how it will unfold, and emotion arises when these expectations are not met. The pleasure of music depends on how well it strikes an optimal balance between aligning with listeners' expectations and properly violating them. According to a theory proposed by British neuroscientist Karl Friston, the purpose of the animal brain is to constantly optimize its internal model and behavior so as to minimize prediction error in sensory input. The brain does not perceive the world passively, but rather proactively predicts the surroundings based on its internal model. For example, when we observe a ball falling toward the ground, the brain predicts how it will fall and bounce based on prior experience. When predictions fail, the brain experiences surprise, and then adjusts the internal model to minimize the surprise. The brain experiences pleasure as it effectively modifies its internal model. In other words, prediction error and the subsequent updating of the internal model imply that learning takes place, leading to a more refined understanding of the world. Too little prediction error means a lack of learning, so the brain finds it boring. On the other hand, too much error implies that the existing internal model is significantly wrong, which causes discomfort and anxiety. Music that partly meets the listener's expectations yet introduces a suitable degree of deviation provides the brain with an optimal level of prediction error.

derive	引き出す、得る		passively	受動的に
unfold	展開する		verify	検証する
align with	～と一致する		refine	洗練する、改善する
violate	（期待などを）裏切る		deviation	逸脱、ずれ
optimize	最適化する		discomfort	不快感
sensory input	感覚入力		auditory	聴覚の

The Human Brain on Music #3

The fact that we can enjoy music derives from the brain's ability to _____ _____________. When music is ____ _____________, we find the music boring, and when the music is ____ ____________, we tend not to like it. In other words, we prefer music with an _____________ ________ between familiarity and ________, simplicity and complexity. To put it another way, musical taste is influenced by not only _______ ________ but also by personal musical experiences, as well as __________ ____ ____________ __________. For example, String Quartet No. 19, composed by Wolfgang Amadeus Mozart in 1785, begins with a heavy introduction marked by __________ _____________, which serves to highlight the _______ _____ ________ that follows. The dissonant harmonies were so shocking and impressive for the audience at the time that this piece was _______ "Dissonance." However, to _______ ___________, it would not seem particularly unusual because, after Mozart, the use of dissonance has become _____________, and our brains have ______ ____________ ____ such music through repeated exposure. Thus, musical taste is also influenced by the cultural and historical backgrounds. The joy of music has a lot to do with our brain's expectations, which are _______ ____ what kind of music we have listened to. In other words, music that ______ ____________ in the future will be that which adds a __________ ______ ____ ________ to the features of music that people are already familiar with. In this sense, musicians may not have ______ ________ ____ __________ in order for their music to be loved by the audience. The trend of music at any given time might be ________ ____________ by this structure.

The fact that we can enjoy music derives from the brain's ability to make predictions. When music is too predictable, we find the music boring, and when the music is too unfamiliar, we tend not to like it. In other words, we prefer music with an appropriate balance between familiarity and novelty, simplicity and complexity. To put it another way, musical taste is influenced by not only innate factors but also by personal musical experiences, as well as cultural and historical contexts. For example, String Quartet No. 19, composed by Wolfgang Amadeus Mozart in 1785, begins with a heavy introduction marked by striking dissonances, which serves to highlight the bright main section that follows. The dissonant harmonies were so shocking and impressive for the audience at the time that this piece was dubbed "Dissonance." However, to modern listeners, it would not seem particularly unusual because, after Mozart, the use of dissonance has become established, and our brains have grown accustomed to such music through repeated exposure. Thus, musical taste is also influenced by the cultural and historical backgrounds. The joy of music has a lot to do with our brain's expectations, which are shaped by what kind of music we have listened to. In other words, music that gains popularity in the future will be that which adds a suitable level of novelty to the features of music that people are already familiar with. In this sense, musicians may not have total freedom of creation in order for their music to be loved by the audience. The trend of music at any given time might be already determined by this structure.

predictable	予測可能な		dissonance	不協和音、不協和
familiarity	親しみやすさ、なじみ		dub	〜と呼ぶ、あだ名を付ける
novelty	新規性		accustomed to	〜に慣れている
innate	生まれつきの		exposure	接触、経験
context	文脈、背景		creation	創作
striking	印象的な		trend	傾向、流行

The Human Brain on Music #4

Understanding music involves various areas of the brain, some of which are also used for ____________ __________. Neurologically, music and language have something in common. One of the most ________ ______________ is the processing of pitch. To understand or reproduce music, one has to ________ ____ ________ in pitch. Spoken language also involves such variations. Spoken language consists of two elements: ____________ ________ and ________. Prosody refers to the combined elements of pitch, rhythm, pauses, and _______ ____ _______. We rely on variations in pitch to ___________ ____ _______ of spoken language. For instance, the exact same sentence, such as "I have just finished the exam" can ________ ____________ ___________ __________ depending on the tone of voice. If the tone is positive, it suggests that the test _______ _____ _____, whereas a ________ _____ conveys the opposite implication. Research indicates that people with musical training tend to show greater ability to _______ ______ ____________ in languages. Furthermore, the ability to perceive pitch is particularly important in __________ _____________ during infancy because children learn the rules of a language with the help of __________ _____. For example, before mastering grammatical rules, infants can __________ _____________ between questions and statements based on the intonation at the end of the sentence. Even before understanding the word order in "Is this a dog?" forms a question, children can recognize it is a question by ____________ ____ _____ ____ ______, and then they _____________ ______ grammatical rules. Thus, prosody is important for both perceiving spoken language and ___________ __________.

Understanding music involves various areas of the brain, some of which are also used for processing language. Neurologically, music and language have something in common. One of the most notable commonalities is the processing of pitch. To understand or reproduce music, one has to capture the changes in pitch. Spoken language also involves such variations. Spoken language consists of two elements: linguistic content and prosody. Prosody refers to the combined elements of pitch, rhythm, pauses, and stress in speech. We rely on variations in pitch to interpret the intent of spoken language. For instance, the exact same sentence, such as "I have just finished the exam" can deliver completely different messages depending on the tone of voice. If the tone is positive, it suggests that the test likely went well, whereas a subdued tone conveys the opposite implication. Research indicates that people with musical training tend to show greater ability to detect pitch variations in languages. Furthermore, the ability to perceive pitch is particularly important in language acquisition during infancy because children learn the rules of a language with the help of prosodic cues. For example, before mastering grammatical rules, infants can innately distinguish between questions and statements based on the intonation at the end of the sentence. Even before understanding the word order in "Is this a dog?" forms a question, children can recognize it is a question by perceiving the rise in pitch, and then they inductively infer grammatical rules. Thus, prosody is important for both perceiving spoken language and acquiring language.

neurological	神経学的な		convey	伝える
commonality	共通点		acquisition	習得
pitch	音の高さ		cue	手がかり
variation	変化、変動		intonation	イントネーション
prosody	韻律、抑揚		inductively	帰納的に
subdued	元気のない、抑えられた			

The Human Brain on Music #5

The joy of music derives from our abilities to ________ ____ ________ its structure, and researchers suggest that this function is similar to ___________ ____________ in language comprehension. When we comprehend language, phonemes are first integrated into words in the __________ _______ of the temporal lobe, after which syntactic processing takes place across a broad network centered on the ________ _____. When we listen to music, the brain __________ _____ _____________, but sequences of sounds are combined in a "syntactic" manner in the frontal lobe directly. We do not perceive each individual note in isolation; rather, we ______ __________ and structures in sequences of sounds to ________ ________. Let us take an example of the famous "Twinkle Twinkle Little Star." When we listen to this piece, the brain ______________ ___________ that it started on C and which other notes were used. Also, the brain ______________ __________ how the melody will unfold based on past musical experiences. When the music __________ ____ ____ as expected, the brain experiences a ______ ____ ________, but if it instead unfolds as *fa–fa–mi–mi–re–re–so*, it gives the impression that the music is ______ ____________. Furthermore, if this piece is arranged in a minor key, the sequence of *re-re-do* at the end _______ __________ ___________ in character, even though it consists of the exact same notes as in the major version. This is because the brain ________ ____ ______________ and interpretations in light of the fact that the entire phrase is in a minor key. A similar process occurs when we hear language. When we listen to the two sentences—"I feel happy when I listen to this music" and "I don't feel happy when I listen to this music"—the brain immediately ________ ____ ______________ for what follows, depending on the __________ ____ ________ of "don't." Thus, comprehending language and music has a lot in common and _______ _____ ______________ ______. This suggests that engaging in musical play may serve as a form of __________ ____ ___________ ____________ in children.

The joy of music derives from our abilities to analyze and predict its structure, and researchers suggest that this function is similar to syntactic processing in language comprehension. When we comprehend language, phonemes are first integrated into words in the auditory cortex of the temporal lobe, after which syntactic processing takes place across a broad network centered on the frontal lobe. When we listen to music, the brain bypasses word recognition, but sequences of sounds are combined in a "syntactic" manner in the frontal lobe directly. We do not perceive each individual note in isolation; rather, we grasp patterns and structures in sequences of sounds to extract meaning. Let us take an example of the famous "Twinkle Twinkle Little Star." When we listen to this piece, the brain unconsciously remembers that it started on C and which other notes were used. Also, the brain statistically predicts how the melody will unfold based on past musical experiences. When the music resolves on C as expected, the brain experiences a sense of closure, but if it instead unfolds as *fa–fa–mi–mi–re–re–so*, it gives the impression that the music is still continuing. Furthermore, if this piece is arranged in a minor key, the sequence of *re-re-do* at the end sounds entirely different in character, even though it consists of the exact same notes as in the major version. This is because the brain adjusts its expectations and interpretations in light of the fact that the entire phrase is in a minor key. A similar process occurs when we hear language. When we listen to the two sentences—"I feel happy when I listen to this music" and "I don't feel happy when I listen to this music"—the brain immediately adjusts its expectations for what follows, depending on the presence or absence of "don't." Thus, comprehending language and music has a lot in common and shares some neurological basis. This suggests that engaging in musical play may serve as a form of training for syntactic processing in children.

syntactic	統語論的な	isolation	孤立した状態
comprehension	理解	parallel	類似点、対応関係
phoneme	音素	resolve	（音楽が）終止する
integrate	統合する	closure	終結感、完結感
auditory cortex	聴覚野	minor key	短調
bypass	飛ばして進む、省略する	presence	存在、有無