frontiers FOR YOUNG MINDS

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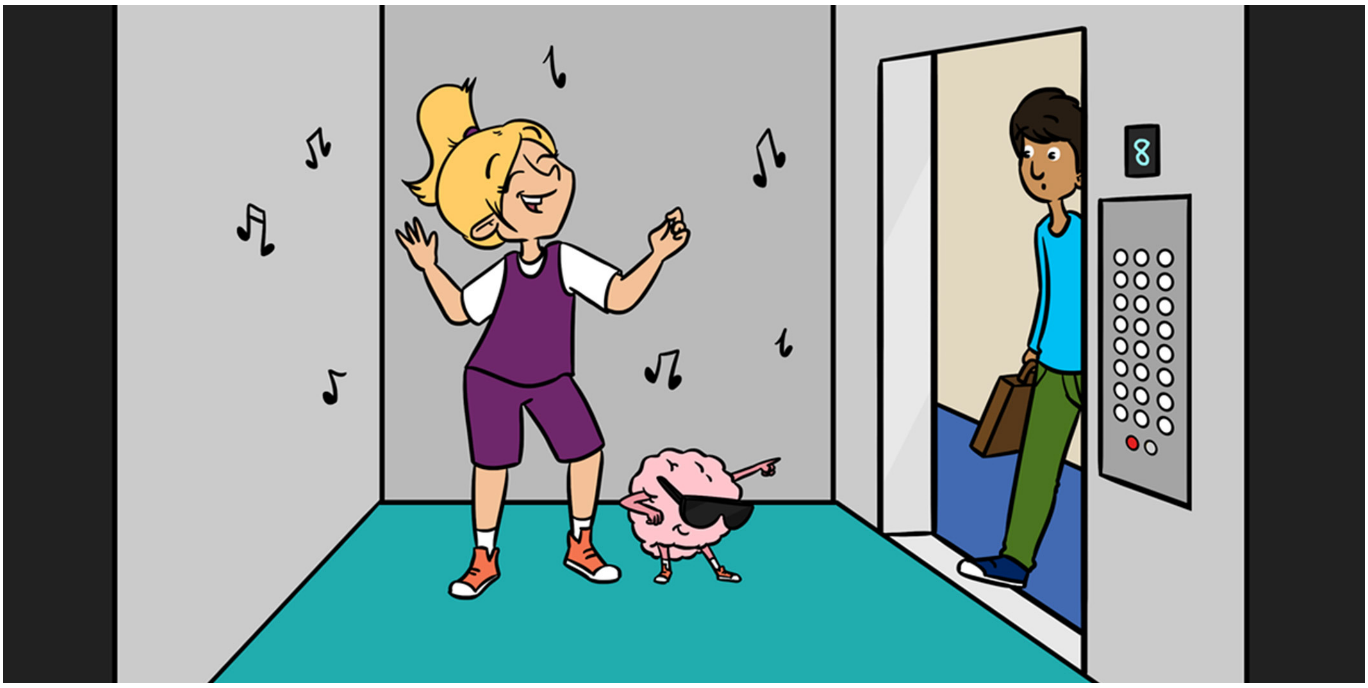

WHY DO HUMANS—AND SOME ANIMALS—LOVE TO DANCE?

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Have you ever lost yourself in dance? Or have you bounced your foot or wiggled with the rhythm of music? Do you find yourself smiling when you do so? You are not alone! From a simple drumbeat to popular rock-and-roll, the sound of music makes people of all ages move along in time to the beat. We see people tapping, clapping, and bouncing when listening to their favorite songs at a concert hall or on their phones. The urge to move with music has been part of all cultures across the world for as long as we have been studying humans. There are even some animal species that like to dance! Why is this? In this article, we explain what it is about music that makes us want to move—and what is happening in our brains when we do. Let us dive into the science behind dance.

Dance means the act of moving one's body rhythmically to music. Music is simply a mixture of sound waves made by a human voice or a musical instrument. Sound waves are invisible and travel through the air and into our ears. When the sounds reach our ears, they send signals to a part of the brain called the **auditory cortex**. The signals then travel to other areas of the brain. Through this process, music "lights up" the brain regions that are responsible for thinking and understanding—and for reward, emotion, language, and movement. Let us find out more about how music affects our minds and bodies!

AUDITORY CORTEX

A brain region that processes auditory information in humans and some animals.

RHYTHM

A broad term in music referring to the certain pattern of sound (note) and silence (rest).

METER (METRE)

In music, it refers to the regularly recurring patterns of stressed and unstressed beats.

RHYTHMIC ENTRAINMENT

A temporal coupling of two independent oscillators, by which one oscillator's frequency entrains the frequency of the other.

VIDEO 1

Rhythmic entrainment of five metronomes on a common base.

OSCILLATOR

An object moving back and forth with a set regular rhythm.

OUR BODIES GET SYNCED TO THE RHYTHM OF MUSIC

When you think about music, you might imagine your favorite song or band. Or you might think about the classical or jazz music you are learning to play on an instrument. A scientist would describe music as a series of sounds and silences that happen in a particular pattern over a certain time period. The pattern of musical sound is called **rhythm**. Most music also has regular beats, called **meter**, which is what makes us want to move our bodies in time with it. It is easy to move to music with a meter because we can guess what is coming next. Our internal body rhythms start to match up with the rhythm or meter of the music. This process is called **rhythmic entrainment**.

Video 1 demonstrates rhythmic entrainment. Have you ever seen an old-fashioned grandfather clock? Hanging beneath the clock face is a long bar with a weight on the end, called a pendulum. As the pendulum swings from side to side, its movements turn a series of cogs, which then turn the hands of the clock. Pendulum clocks were invented in 1666 by a Dutch physicist, Christian Huygens. Huygens placed two pendulums on the same wall and started swinging them at different times. Soon, the two pendulums started swinging back and forth in time with each other! They had become synchronized. This is a great example of entrainment. How does this happen?

An object moving with a set rhythm, like the pendulum of a clock, is called an **oscillator**. The word "oscillate" comes from the Latin word "oscillat" which means "to swing." When the pendulums start to oscillate, they transmit small amounts of energy to each other through the base they are standing on. When one pendulum swings, it creates energy that is transferred through the base to the second pendulum. When the second pendulum swings back, it also makes energy and passes it back to the first pendulum. It is a bit like two people having a conversation. As this small energy exchange repeats, it gradually changes how quickly each pendulum oscillates. The faster oscillator slows down, and the slower oscillator speeds up, until they move at the same speed. Once the oscillators are synchronized, they stop transmitting energy between them. Being synchronized uses the least amount of energy.

Many things in nature have their own rhythms. From the tiniest atoms to our own heartbeats or breathing, the world is full of things that oscillate. Rhythmic entrainment—synchronization—is happening all around us every day, including when we listen to music. The oscillator of the body becomes entrained to the rhythm of music. Our feet begin to tap or stamp, we bounce up and down, or we walk along in time to the music, the same way the pendulums started moving together in Huygens' experiment. Even our heartbeat and breathing can start to keep time with the music [1]!

OUR MINDS EMOTIONALLY BOND TO MUSIC

We now know why we move along in time to music. But why do we *enjoy* dancing so much? For centuries, psychologists (who study our thoughts and behaviors) have been interested in how music affects our emotions. Most forms of music express emotions through tempo, melody, and rhythm. Think about a cheerful song. Is it fast or slow? Is it upbeat or down? Now think about a sad song. Is it different from the happy song? A happy birthday song might make us feel good because the melody and rhythm are happy and bright and because we often hear or sing that song when having fun with family or friends. We associate the birthday song with good times, so when we hear it, we remember those times and feel happy as a result!

The way we move our bodies is deeply connected to our emotions and feelings. When we are happy, we might jump around or wave our arms in the air. When we are sad, we might hunch over or fold our arms around our bodies. But the opposite is also true. Hunching over and wrapping our arms around our bodies can *make* us feel sad. Jumping around and waving our arms can *make* us feel happy! Expressing our emotions through movement is called the **embodiment of emotions**.

EMBODIMENT OF EMOTIONS

The physical representation or expression of one's emotional states.

Music is a great example of the embodiment of emotions. This is because music performers express emotions through movements, which causes listeners to have similar emotions. So, listening to jolly music can make us feel happy and move our bodies in a jolly way by jumping, clapping, or singing along, which makes us feel even happier! Think about how a ballet dancer might move to a slow, sad tune. Or how a rock star might bounce to a happy, energetic song. In this way, we can use music and movement to show others how we feel. In essence, we move to music to express, experience, and enrich our feelings through melody or rhythm. Scientists have confirmed that music helps us feel and express our emotions. So, when we dance to upbeat music, we can not help feeling happy!

PRIMARY MOTOR CORTEX

A brain region that provides the most important signals to produce skilled movements.

LIMBIC SYSTEM

The collection of brain structures that are involved in emotion processing and behaviors.

MIRROR NEURONS

A set of neurons in the brain that modulate a specific action in humans and some animals or when they observe the same or similar action in others.

MUSIC LIGHTS UP THE BRAIN

The brain region that causes movement is called the **primary motor cortex**. When we hear music, this part of the brain is activated and encourages us to move. Another brain region is also at work when we listen to music—the **limbic system**, which is the part of the brain associated with reward and emotions. The limbic system triggers the release of body chemicals called hormones, which make us feel good. So, listening and moving to music can cause our bodies to release feel-good hormones. When moving our bodies in time to music, our feelings and emotions also bond with the music.

Psychologists think that brain cells called **mirror neurons** also play a role in our enjoyment of music. Mirror neurons are brain cells that are activated when we see other people doing something [2]. For example, if your friend yawns, your eyes see them opening their mouth wide and your ears hear a yawning sound. This triggers mirror neurons in your brain that make you want to yawn, too! Try fake-yawning in front of a family member and see what happens!

Mirror neurons also help you experience what is expressed by music performers. For example, when watching a band, your mirror neurons might encourage you to play air guitar while your favorite rock star is playing *real* guitar. Making similar movements to people performing music helps us relate to the emotions the musicians are expressing [1]. When several people move and feel the rhythm and emotions of music at the same time, their brains mirror each other's behaviors and they become socially bonded. See Figure 1 for an overview.

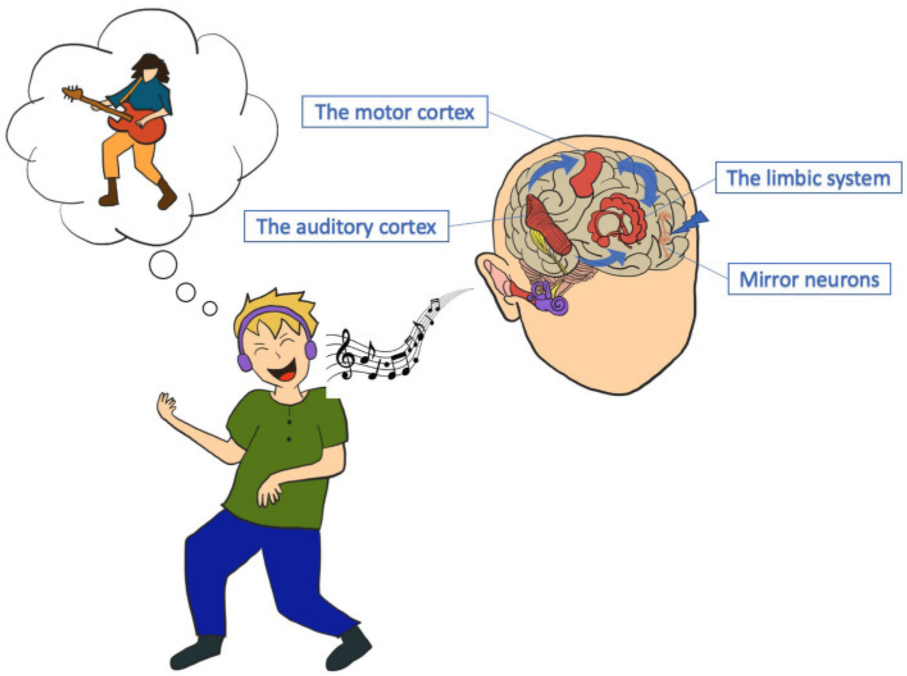

Figure 1

Figure 1

A person playing air guitar. The auditory cortex interprets the rock music and delivers the signals to the limbic system and the motor cortex, to create emotional and motor reactions. Mirror neurons play a crucial role in this process, helping to mimic the motion of guitar playing and reflect the feelings of the musician (Image credit: Jiyeong Hong).

WE ARE ALL BORN TO ENJOY DANCING

We now know why people enjoy listening and moving to music. Our dance moves might improve as we get older, but we are all *born with* the ability to dance. Scientists studied infants 5 months to 2 years old [3]. They played a variety of music, including classical pieces by Mozart and Saint-Saëns, children's songs, and drumbeats, as well as non-musical sounds like recordings of people talking. They found that babies moved more rhythmically when hearing music than when hearing non-musical sounds, and they smiled more when moving with music! These findings show that people are literally born to enjoy dancing, although everyone has their own unique desire and ability to dance. See Figure 2 for an overview.

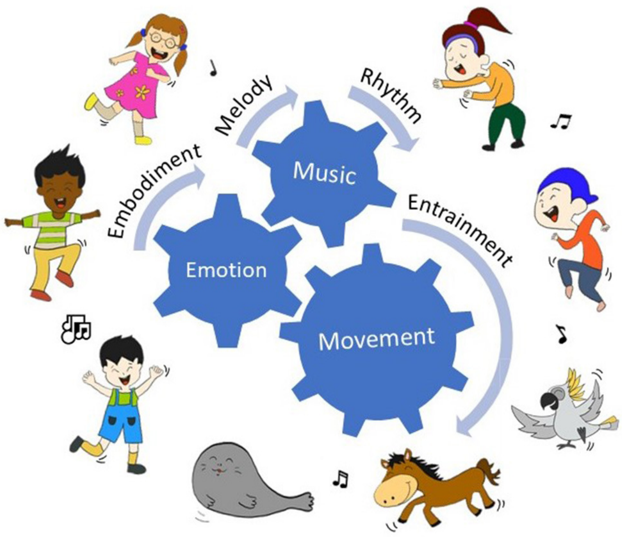

Figure 2

Figure 2

Dance often demonstrates our emotional and motor (movement) reactions to music. It is universal across most human societies and cultures. Entrainment and embodiment play a crucial role in dancing. Dancing has also been observed in some animals, although animals may not have sophisticated feelings like humans (Image credit: Jiyeong Hong).

SOME ANIMALS CAN DANCE, TOO!

Studies have shown that it is not just humans who dance. Some animals can entrain to music too. The most famous example is a parrot called Snowball (Video 2), whose movements consistently matched the rhythm of music in an experiment [4]. Some other examples of dancing animals include a sea lion (Video 3) that bobbed its head to a metronome and other rhythms, a bonobo that spontaneously drummed in synchrony with a scientist, and a horse that seemed to be trotting in time with music [5].

VIDEO 2

Snowball's tribute to Michael Jackson.

VIDEO 3

A scientific recording of a sea lion's beat keeping.

Scientists have suggested that animals may learn to move to the beat of music for food rewards or social bonding. The sea lion was trained for months with rewards of fish, and the parrot was rewarded with praise, which made it feel close to its human trainers. For us humans, engaging in music and dance helps us bond with others, contributing to the formation of unique cultures over thousands of years [5].

CONCLUSION

There is still a lot to discover about how humans and animals engage with music. Based on our current knowledge, we now understand that almost all humans and some animals can move to music. They choose to do so because it makes them feel good. Hopefully, in the future, you might join us to explore the science behind dance and music.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Aya is a 14 year old who loves biology, especially anything related to cells. She also loves books, sci-fi and R&b. Outside of school, she spends her time reading, playing volleyball and exploring molecular biology!

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Madeleine is a neuroscientist with a focus on the development of rehabilitation programs for older adults with neurodegenerative diseases. She has a degree in dance performance from Tisch School of the Arts of New York University, and she had a successful ballet, ballroom, and contemporary dance career prior to returning to graduate school. Then, she completed her Ph.D., in Movement Science at Washington University and completed postdoctoral training in geriatric rehabilitation at the Atlanta Veteran's Administration Hospital and Emory University. She is currently an associate professor of medicine at the Emory University School of Medicine, Department of Medicine, and a research health scientist at the Atlanta Veteran's Administration Center for Visual and Neurocognitive Rehabilitation. She and her husband love moving to music with their two awesome children, Marcel and Mary Celeste.

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Christina is an associate professor of gerontology and geriatric medicine at the Wake Forest School of Medicine. She is interested in the relationships between the brain and aging-related changes in metabolism and movement. The natural course of aging can change the way the body uses fats and sugars and increase the risk for obesity and type 2 diabetes. Aging also increases the risk for slower gait and the chances of falling. Healthy exercise and eating can help preserve and recover both cognitive and physical function as people age. Her lab is interested in studying the effects of various lifestyle choices on both the body and the brain in aging, to help people live fulfilling lives.

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Christina is the vice provost of the arts at Wake Forest University and an associate professor of dance. She studies the ways movement and dance can improve the mobility, balance, cognition, and quality of life of older adults living with diseases like Parkinson's and Alzheimer's. She is fortunate to do this work with a brilliant neuroscientist, also named Christina, who is also a co-author of this paper!

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Jenny is a distinguished professor and the chair of the Department of Kinesiology at the University of North Carolina at Greensboro (UNCG). Before joining UNCG, she received her degrees from the University of Tennessee (B.S.), University of North Carolina-Chapel Hill (M.A.), and Arizona State University (Ph.D.). Jenny has over 80 publications in the fields of exercise sciences and cognitive psychology and also wrote the book *Bring Your "A" Game: A Young Athlete's Guide to Mental Toughness*. Jenny and Shin have been working on developing music-based exercise programs for middle-aged and older adults with and without medical conditions.