

EVERY BRAIN NEEDS MUSIC



*The Neuroscience of Making
and Listening to Music*

LARRY S. SHERMAN
and DENNIS PLIES

With Illustrations by Susi B. Davis

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*We dedicate this book to our partners in life,
Diane and Barbara,
to our children,
Benjamin, Claire, and Alanna,
Matt, Dan, Melanie, and Rachel,
and to
teachers and students everywhere.*



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PRELUDE

A NEUROSCIENTIST AND A MUSICIAN WALK INTO A BAR GYM



BEFORE WE move to the overture, allow us to introduce who we are and how this book came to be. It started when a neuroscientist and a musician walked into a gym very early one morning. Dennis, a professional musician, music teacher, and former professor of music at Warner Pacific University in Portland, Oregon, found Larry, a professor of neuroscience at the Oregon Health & Science University School of Medicine, first on stage (fully clothed) at his “Music and the Brain” lectures, and then in the locker room at 6:00 a.m. Through many subsequent discussions in that locker room, we bonded over our shared love of history, literature, science, and everything there is to know and learn about music.

This unlikely beginning led us to where we are, presenting you with *Every Brain Needs Music*, our book examining how the human brain interacts with music through wholehearted

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listening, singing, and—most effectively—learning to play a musical instrument.

So just who are we?

DENNIS

Saying that I love music is an understatement. At age three, I was a serious listener begging for piano lessons. I began marimba lessons at six, added piano at age eight, and added trumpet at ten, and I continued to study, practice, and play all three instruments throughout my youth. In college, I majored in the pipe organ. I eventually realized that helping others understand and perform music (especially classical and jazz idioms) was just as rewarding as participating in stage, television, and radio performances. I became a professor at Warner Pacific University, where I loved teaching aural skills and piano and directed jazz ensembles, including singers and instrumentalists, for over thirty-seven years. In short, I *love* making music, teaching music, playing music, and performing on stage for audiences.

LARRY

This book is a natural extension of the talks on the neuroscience of music I have been giving for more than a decade, as well as of my own laboratory research. As a professor at the Oregon Health & Science University, I study ways to repair brain damage in people with diseases like multiple sclerosis and Alzheimer's. In particular, I study how processes like

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myelination, neurogenesis, and the functioning of neurons, topics covered in this book, are regulated in development and disease.

Growing up in La Jolla, California, I loved to tinker at the piano from an early age. At six, my parents took me to see a live performance of *Brigadoon* at Balboa Park's Starlight Bowl in San Diego, a fantastic outdoor venue for musical theater. When we returned home, I went directly to the piano and started playing the melodies from memory. I took piano lessons for years until my teacher, frustrated with my tendency to play by ear instead of reading assigned sheet music, advised me to "go out and play in a band or something." I took this advice, in rock and blues groups off and on through my adolescence and adult life. I eventually combined my passions for neuroscience and music to develop a talk, and now—with Dennis—a book, on music and the brain.



We hope that the interweaving of music experiences, music teaching, and neuroscience will offer readers unique insights into music, the art of teaching, learning, and creativity. Rather than presenting an extensive review of musicology or of the neuroscience of music, we hope that *Every Brain Needs Music* will serve as an introduction to the big questions in these fields and will be of interest to anyone who loves music and is interested in gaining insights into how we create music, teach and learn music, and perform and listen to music. However, you may apply the discussions in all the following movements to how

PRELUDE

humans teach and learn in general and to the underlying nature of creativity itself. Finally, we hope that this book shows why you should never be afraid to have meaningful conversations with someone when you're standing, naked, in a locker room at six in the morning.

OVERTURE

THIS BOOK involves the collision of two worlds that cannot live without each other: the world of the human brain and the world of the music that the brain creates, performs, and enjoys. It is a tale of the nerve cells and circuits that allow performers from Pharrel to Prokofiev to compose and perform their musical creations. It is also the tale of every music student and teacher seeking to perfect how the student plays an instrument or sings. It is the story of listening to a song by Elis Regina or Scott Joplin that makes your body involuntarily move to the beat, or to an Amália Rodrigues or Alison Krauss song that makes you cry. By the end of this journey, you will better understand how human beings create, practice, perform, and listen to music. You will also gain insights into how the neuroscience underlying these activities can help you appreciate the origins of your own creativity, inspire approaches to teaching and learning, and reveal whole new ways to appreciate the music and other art around you.

OVERTURE

Before we began writing this book, we developed a survey that was sent to over one hundred composers, musicians, and music lovers to try to understand the many ways people experience and engage with music (appendix A). The rich and enlightening responses to our survey guided the writing of each movement. Dennis examined the answers through the lens of his experience as a teacher, performer, and lifelong student of music. Larry wrote about the processes and changes that occur in our brains when we compose, practice, perform, and listen to music. So the voices guiding you in the movements that follow are a combination of these survey responses and Dennis's and Larry's experiences, thoughts, and critical reviews of relevant literature.

The journey starts in the first movement, where we explore what music is, the origins of music, the reasons for music's existence, and the ways that humans have used music since the dawn of humanity.

Next, the second movement looks at how the human brain creates music. We focus on the processes of improvisation and composing, discussing their similarities and differences. We examine how areas of the brain that regulate functions ranging from empathy and impulse control to basic decision-making play major roles in music making. We also explore how the brain can create music alone or in a group of brains, and which of the brain's areas must communicate with one another when creating music, be it for a piano or a Chinese zheng.

The next three movements focus on how we teach music, how we learn to play a musical instrument or sing, and the many circuits in our brains that must communicate with one another

OVERTURE

as we practice. We follow the path from the light reflected off a page of written music to the parts of the brain that interpret what was written on that page, then to the parts of the brain that control our movements, and finally to playing or singing a note. We discuss the characteristics of a good music learner and a good music teacher, and how a motivated music learner literally rewires their brain when learning to play an instrument or to sing.

In the sixth movement we look at how the effort invested in practicing music culminates in a performance. We discuss how performing music for oneself or for an audience differs from the processes of learning to play and practicing. We address how the brain reacts to the environment where music is performed and what happens in the brain when someone experiences stage fright. We also explore the relationship between musicians and their audience, and how their brains interact with one another to influence a performance.

We dedicate the seventh and eighth movements to how the brain listens to music and how the brain comes to like or dislike different types of music. We explore how a source of music—whether instrument, voice, or recording—alters the movements of air molecules that enter the ear and stimulate specialized nerve cells that travel to many different parts of the brain, helping us perceive what we call music. We also explore how these vibrating air molecules can have powerful effects on our emotions and our sense of well-being, finally returning to the question of why music exists.

We wrote *Every Brain Needs Music* to inspire you to think about how music, like other forms of art, comes to be created

OVERTURE

and perceived in the human brain. We hope it helps you consider how challenging your brain to learn something new that involves movement, sensation, and cognition can lead to remarkable changes not only in the structure of your brain but also in who you are as a human being. And now, in the words of Mack David and Jerry Livingston, “On with the show: this is it!”

EVERY BRAIN NEEDS MUSIC

First Movement

WHAT IS MUSIC, AND WHY DOES IT EXIST?

IF AN EXTRATERRESTRIAL ALIEN landed in your backyard and (assuming that the alien somehow learned a language that you know) asked you to describe music using words, what would you say? Robert Fripp, guitarist, composer, and member of the progressive rock band King Crimson, once said, “Music is the wine that fills the cup of silence.” That sounds lovely, but it is far too poetic for neuroscientists (like Larry) and neuroscience-curious musicians and musical academics (like Dennis) doing a deep dive into what music is to the human brain. For the purpose of this book, we will define music more along the lines of pioneering rock musician Frank Zappa, who declared that “a composer is a guy who goes around forcing his will on unsuspecting air molecules often with the assistance of unsuspecting musicians.”

Indeed, the music generated in the mind of any human and performed by that human or by others (either live or through a

recording) leads to a series of changes in the vibrations of molecules that travel through the air at around 343 meters per second (about 1,235 kilometers per hour or 767 miles per hour, to compare the speed of sound to how fast you drive a car). So, in one sense, music can be defined as the changes experienced by air molecules over time when singers sing or instrumentalists play their instruments. But if all of these changes in air molecules occur in a forest and there is nothing there capable of perceiving the patterns of these molecules as music, is there music?

The changing properties of these air molecules must somehow be detected and interpreted as music. But how? The answer is the human brain. Our brains are who we are, functioning as ever-changing computers that allow us to perceive the world around us, respond to what we perceive, and imagine and create art, literature, and music that the brains of others can perceive. For example, the brain of a composer who has spent many hours creating new music passes that information on to the brains of musicians who spend many hours practicing and interpreting that music, eventually performing that music for the brains of an audience. Each step of the way, these experiences result in both short- and long-term changes to those brains. Thus, beyond altering the behaviors of air molecules, to understand what music is we must understand how our brains perceive and respond to it.

Throughout this book, we will look at how different areas in the brain change by creating, practicing, performing, and listening to music. Distinct brain areas comprise different collections of cells that interact with one another within a given area but that also form connections with other parts of the brain, in turn

WHAT IS MUSIC, AND WHY DOES IT EXIST?

forming networks of circuits that influence learning, memory, movement, sensation, and cognition.

At first glance, the human brain is a structure with many bumps (called *gyri*) and grooves (called *sulci*), some of which divide the brain into four major lobes (figure 1.1). The *frontal lobe* is where “executive functions” occur, including emotional regulation, planning, reasoning, and problem solving. It also controls voluntary movement and activity. The *parietal lobe* processes information about our sensations of the world, including temperature, taste, touch, and movement, while the *occipital lobe* is primarily responsible for vision. The *temporal lobe* processes memories, integrating them with sensations of taste, sound,

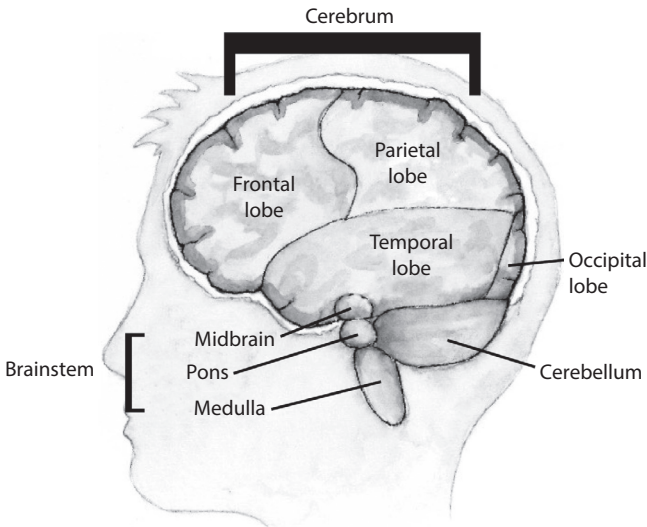


FIGURE 1.1 Major areas of the human brain. (Illustration by Susi Davis)

sight, and touch. It also contains the *auditory cortex*, which processes sound. Other major brain areas include the *brainstem*, which has many functions and connects the brain to the spinal cord, and the *cerebellum*, which coordinates voluntary movements such as posture, balance, coordination, and some aspects of speech and sound processing, including music.

These major brain structures, and many smaller structures within them, function differently from and in conjunction with one another to perceive and react to the many changes imposed on air molecules over time by music, allowing our brains to understand that what we are hearing *is* music. These structures also allow us to compose, learn to play, practice, and perform music.

NEURONS: THE ELECTRICAL UNITS OF THE NERVOUS SYSTEM

Weighing in at roughly 1.5 kilograms (3.3 pounds), your brain contains approximately 171 billion cells.¹ Around 86 billion of those cells are *neurons*—the major electrical units of our nervous systems. Neurons form the circuits that allow different brain areas to perform their functions and to communicate with one another. Neurons respond to the world around us, including to music.

Neurons have a unique structure compared with other cells. As shown in figure 1.2, this structure includes the *cell body*, which includes many tiny cellular parts that allow neurons to use energy and perform their various functions, as well as the *cell nucleus*, where the cell's DNA (deoxyribonucleic acid) is found, encoding everything cells need to function.

WHAT IS MUSIC, AND WHY DOES IT EXIST?

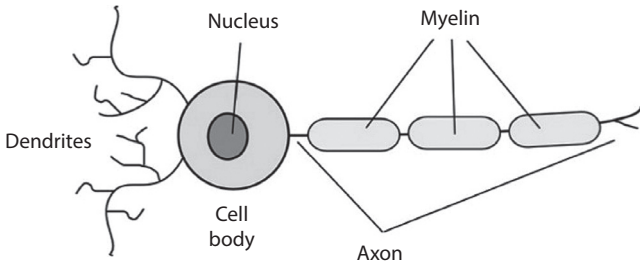


FIGURE 1.2 Structure of a typical neuron.

Extending from the cell body are branched structures called *dendrites*. The dendrites on any given neuron may be short or long, simple or highly branched, depending on where they are and what they need to connect with elsewhere in the nervous system (figure 1.2). Electrical signals enter neurons through dendrites. The signals are then passed along through an *axon*, a special branch that is also connected to the cell body; the axon is often surrounded by a substance called *myelin* (more on that in later movements). So, for any given neuron, nerve impulses coming from other neurons travel along the dendrites, then through the cell body, and then along the axon, which transmits the impulses to the dendrites of other neurons.

NEURONS TALK TO ONE ANOTHER, FORMING THE CIRCUITS OF OUR NERVOUS SYSTEMS

These connections between the axons of one neuron and the dendrites of another form the circuits of our brain, allowing us to do all the wonderful things that make us human, including