Hey friend!

Thanks for subscribing, and for your interest in **how** changing your brain can make your singing AWESOME!

This chapter is *brand new!* It hasn't been edited, or even shown to my cadre of voice pro pals (who promised to be merciless). If you have feedback for me, I want to hear it!

Now that you're on my email list, you'll be able to **help me name** my book, AND have access to the **presale release**!

(I don't actually know how a proper book release works, so there may be more. Stay tuned.)

Meredith

Sidebar:

> Whenever you're delving into neuroscience remember that the actual brain models we use are animals and cadavers. We know a lot about mouse brains! With very few exceptions, the ways science has learned about living human brain activity is via functional neuroimaging such as fMRI, PET scans, or behavioral research. And even there, bear in mind that the large majority of behavioral research is done on comparatively rich, educated, first-world adolescents (undergraduates) so the data is inherently skewed. There is still much to be learned! The human-computer interface technology that's being developed as this book is being written may offer us new insights into how our brains function.

3 Things about Brains & Singing

Because NeuroVocal was developed with microphone singers in mind, it was also developed to be reliable for singers in amplified situations.

As I detailed in [Chapter X (6? Pulling back the curtain], singing is a predictive-processing loop; the singer is hearing their voice and filtering the sound through their unique learned listening. This learned listening includes concepts, such as aesthetics about desirable sounds and musical values. Those things are tied together with the brain's internal model of how the sound is being generated, and the prediction machine is in motion.

Most of the time that prediction machine is so smooth you don't notice it. When the sensory data being delivered to your fancy auditory processing system is unfamiliar, though, or there's simply too much sensory data coming at you, it becomes much more difficult for your brain to rely on predictions. When that happens you're likely to unconsciously compensate for that. You may sing with an unnecessary degree of effort, for instance, or have an emotional response such as feeling unsure or frustrated.

Now that you know all about brains, I'm going to let you in on three things brains do. Once you know, I'm going to suggest an alternative approach to singing that's more enjoyable because it's more predictable.

The first thing: Intero-what?

Interoception is the ten-dollar word that I'll be using as we move through understanding the processes involved in NeuroVocal.

There's a piece of real estate in your brain called your *somatosensory cortex*. The processing that happens there has to do with how you feel, and how things feel to you.[1] The umbrella term for all that is *somatoception*. The "feels" under that umbrella are:

- Proprioception: balance, the position of your body in space
    - Proprioception is the reason you know where your feet are as you walk without looking at them, or you can lift your cup to your mouth with your eyes closed using just the right degree of force so you don't either dribble or crack your teeth.

[1] As was noted in Chapter X(7? Some brain stuff), your brain is a network. While the somatosensory cortex would be considered the processing area for this type of activity, we are aware of our bodies and feelings through an integrated neural network.

    - Proprioception is an unconscious ability that results from sensory stimuli. Though they are often used interchangeably, it's not the same as kinesthesia. Kinesthesia refers to an awareness of *how* a movement is being performed. Physical disciplines, such as playing an instrument or sport, use both proprioception and kinesthesia.
    - Proprioception, like all sensory experiences, is unique to individuals. Age, neurotype, experience, and physical health will affect proprioception.
    - Fun fact: proprioception can also extend beyond your body when you're in a car, using a wheelchair, or on a bike.
- Exteroception: all the sensory information you get from outside your body such as what your body perceives through vision, hearing, touch or pressure, heat, cold, pain, smell, and taste.
    - Exteroception describes both your environment and your body in relation to your environment. This is a big deal in performance situations!
    - Each of these senses has its own name and dedicated receptors.
    - Fun fact: people have no receptors for "wet." We perceive wetness based on other sensory cues.
- **Interoception**: *how things feel inside of you*.

- Like the other ‘ceptions, interoception represents a number of sensory processing systems, some of which we can be aware of and most of which we are unaware of.
- Interoception is the tool your body uses to achieve homeostasis, or how your body self-regulates to maintain physiological stability.
- People have different levels of interoceptive awareness, and can be aware in different ways. Some people don’t notice when they’re hungry, for instance, or don’t notice an injury until they see the bruise on their skin. Some people can sense their heartbeat so strongly that it can trigger anxiety.
- **Interoceptive awareness can be both consciously and unconsciously affected to be more or less sensitive.**

Why should singers care about interoception?

In the last chapter [or what is currently called “some brain stuff” if we move things] I explained that your brain “budgets” your energy resources, and manages how those resources are “spent.” Interoception is what your brain uses to do that. Your brain is constantly receiving interoceptive messages that help you

manage how your body is using resources like oxygen and glucose, and when it needs something, like food or rest.

The huge majority of these interoceptive conversations between your brain and your body are constantly running in the background, just taking care of business. Sometimes, though, your brain gets interoceptive messages that you *are* aware of. For instance, although you're normally not aware of your stomach, you will become aware of it if you're hungry, or if you have a stomach ache. Interoception tells you all is not well in your tummy. The same can be said for your breathing or your heartbeat. You're not typically aware of these movements in your body, but you can be. Sometimes we can be aware of *interoceptive* messages from our bodies.[2]

Singing is movement. To sing, you have to move parts of your body to generate sound. That sound creates movements (vibrations) in the air that you're streaming through your resonators (your face, mouth, and throat). The physical and vibrational movement of singing creates a twofold movement system that amplifies your opportunity to have an interoceptive experience. The great news about that is that you have nerves throughout your face and head

[2] Fun fact about interoception and singers: Many of these interoceptive messages about the state of your body are sent between your body and brain via the vagus nerve. (See *The Mind-Gut Connection* by Emeran Mayer, 2016, as well as various easily available videos) The vagus nerve is also the sole source of innervation of the larynx. It's the nerve that makes us sing. Someday I hope to write an entire book about this one footnote.

that can sense these movements and vibrations; you can *teach your brain* to be aware of those interoceptive messages.

You may be one of those singers who already experiences their singing in an interoceptive way, through vibrations in your face or throat, or specific feelings in your larynx. That's great! You're already out in front! Now let's explore why you have that ability, and how to turn it into your singing superpower!

The second thing: Down motor memory lane

When we think of a memory, we tend to think of it in a certain way. You remember that trip to Toronto, a record player your uncle had, or how you felt when an audience applauded you for the first time.

Folks in the sciences, not surprisingly, think of memories differently than that. The field of how people create and use memories can be massive and in-depth. We won't dig deep, but I do want to explain just a little about long-term motor memories so you'll have some context for how memories apply to singing.

As you have and create experiences, your brain *encodes* that information. That means that it "translates" the sensory input into a form that it can use to make sense of your experiences as well as to make memories.

The first stop on the encoding train is called short-term, or *working memory*. That's your brain's notepad, where it temporarily holds necessary information to allow you to move seamlessly through your day. Whether or not the stuff on that notepad gets turned into long-term memories depends on what you do with it.

Long-term memories are generally categorized into conscious and unconscious memories. There are two basic kinds of conscious, or *declarative* memories:

- Semantic memory: This is your memory for facts. Information, figures, dates, lyrics, and the kinds of things you memorize and which do not need to be tied to a certain time or place. Semantic memories can be both acquired and lost quickly, and acquired over time and long-lasting.
- Episodic memory: This is your memory for unique events, usually autobiographical. These memories are contextual and can be extremely personally relevant. Often, these memories include emotions, and sensory input (the smells, the song they were playing) that we associate with that event.

The star of our show is an unconscious memory:

- Motor memory: Also called procedural memory or implicit memory, and commonly referred to as "muscle memory," motor memories are unconscious, long-term memories. These are memories for how you do things, both simple and complex, and

are formed through experience and repetition. Once a motor memory is formed, that action feels like it's automatic; it's not something you have to think about.[3]

Spotlight on our star

When you move, your brain uses sensory data about your environment and memories to predict your movement.

Movements can be as simple as walking, lifting, or sitting, and as complex as dancing, figure skating, or singing. Whenever you repeat a complex movement a number of times, your brain learns how to predict that movement. It bundles all the individual movements within that complex movement to create a motor memory. Over your lifetime, you've amassed a huge library of these motor memories.

Creating a motor memory can sometimes be a bumpy ride. When you were a toddler learning to use a cup, you probably spilled as much on your clothes as you got into your mouth. If you've ever learned something difficult, such as playing an instrument or a particular athletic skill, you know that it takes a while to get the

[3] Neuronerds will enjoy a short article and video from one of my fave websites, neurosciencenews.com. The article, from July 2022, is called *Observing Memory Formation in Real Time.* It reports on research at Stanford University that identifies the creation of motor engrams, or motor memories. In this work, the researchers were able to "tag" specific neurons that were activated when a new motor skill was learned, and observe their reactivation when the learned skill was executed. Yes, there's a video!

hang of things. From the simple to the very complex, motor memories take time and attention to build.

Motor memories are, by definition, unconscious. That means that if a behavior is easy and natural for you, you have a strong motor memory for that thing. If something feels tricky, you have to really pay attention as you do it, or doesn't work the way you intended, that means you do not have a motor memory for that thing. It may mean you're in the process of *forming* a motor memory, but it's not yet locked into place. Once your behavior seamlessly matches your intentions, once you don't have to think about the thing anymore, then you know you have motor memory for that thing. Motor memories hide in plain sight.

Talented people

Why does it seem like some people are naturally talented at skills that require motor memories? We don't know. Studies have shown that certain factors influence what we call talent, such as genetics and early exposure to music and singing. We also know that success begets confidence, so the person to whom a skill comes easily is more likely to try other new, related skills. But if you're wondering why singing is so easy for some people and not for others, you may have to keep wondering for now.

Motor memory demo

If you'd like to experience what a motor memory feels like, do a little two-part experiment with me.

Part 1: First, find something that you could pretend is a toothbrush, like a pen or pencil. (No, really. Do it.) Now, take your pretend toothbrush and use it outside of your mouth to pretend to brush your teeth. Pay attention to this movement. It's so natural that you could probably do something else at the same time, like put some socks in the laundry, pet your cat, or read this book. Easy-peasy, right?

Part 2: Now hold your pretend toothbrush *in your other hand* and pretend to brush your teeth for 30 seconds or so. If you're like most people, "brushing" with the opposite hand feels very different from brushing with the hand you're accustomed to using. It probably feels pretty awkward. And if you *were* going to try to brush your teeth this way, you'd really have to concentrate to make sure you did a good job. The socks and the cat would have to wait until you were done.

That was it! You just demonstrated how a motor memory works![4] You have a very strong motor memory for brushing your teeth with your tooth-brushing hand. The ease and familiarity of that movement are evidence of a strong motor memory. When you intend to brush your teeth, your brain accesses that motor memory, and you experience that activity as normal, everyday behavior. If it ever happened that, for some reason, you had to change the way you brushed your teeth, it would take some time for you to adopt a new way of doing that. You'd have to alter your motor memory for "how I brush my teeth".

Motor memory for singing

You probably started singing when you were itty-bitty. Your family may have been musical, or you just loved to sing so you sang! As you got older you started singing along with your favorite songs, recorded by professional singers. You may also have sung with a choir, or in shows, or with your family on karaoke night. Those concerts in your bathroom mirror may have been the launch pad of your solo career.

As you sang, you were building a motor memory for singing. If you couldn't hit the notes the pro singers were hitting, or you couldn't

[4] If you are one of the lucky few who is an ambidextrous tooth-brusher, simply try this same A/B test with your signature. Sign the way you always do, then switch hands!

sing in the way they sang, you compensated for that. You unconsciously created habits around singing that let you sing and, hopefully, enjoy singing. Whether it was in choir, a show, a band, an acapella group, or as the star of your own bathroom concerts, you were making singing happen the best way you could!

All those hours spent singing were building your motor memory for singing. That motor memory is complex, predictable, automatic, and unique to you.

The third thing: your brain plans ahead

In the last chapter [Ch. 7 “some brain stuff” if we move things] I explained that brains predict things. Not just our brains. All brains. You experience the predictive nature of your brain when you have a sense that you know how to do things, from the simple to the complex, experience needs like fatigue and thirst, or form thoughts and turn those thoughts into words.

Your brain has to do the thing before you do the thing. When you sing your brain has to sing first. The time between your brain predicting, your motor memories being accessed, and you taking the action to sing is measured in milliseconds.

That may seem inconsequential. A millisecond is so short we can't even imagine it. But even though a millisecond is shorter than we can imagine, it matters. Because the singing still happens in your brain before it can happen in your body. **Your brain has to predict your singing before you can sing.**

What is generally understood about our day-to-day experience is that it is predictive in nature. Your brain takes sensory input from both your external and internal senses, combines that input with a memory or memories, and predicts what to do about it. Walk, stretch, look, drink, cough, or any of the other ways you naturally use your body. In the case of conscious action, sensory input is combined with intention and attention, you add a dash of memories, both conscious and unconscious, stir in a prediction based on those available data sets, and voila! You've done something on purpose!

There will be more about that "intention and attention" part later because it's a human superpower and an important part of the changes that NeuroVocal offers. But first, let's spot-check the three things you'll want to remember about brains and singing:

- *Interoception is a thing*: *Interoception* is the performing singer's important new vocabulary word. It refers to the brain's ability to sense what is going on inside the body. Its meaning encompasses all of the everything that goes on

inside you, whether you can feel it or not. For the sake of this book, I'm going to parse it out. **In NeuroVocal, and for ease of communication, interoception will refer to *the ability to sense movement going on inside the body*.**

- *Motor memories*: There are different kinds of memories, and motor memories are your unconscious memories for how you do stuff. As you repeat a behavior over and over, the discrete actions involved in the behavior are bundled together as a unified whole. With repetition, for instance, guitarists and pianists find that their fingers "know" where to go on the fretboard or keyboard with little to no thought given to how to do it.
- *Predictive brain*: Something that, more and more, is becoming accepted in neuroscience is that brains are predictive, rather than reactive, in nature.[5] Actions, thoughts, emotions, motivations, interactions, and words result from our brain's best guesses based on its existing memories, which include experience, knowledge, beliefs, and perceptions.

[5] Can brains be reactive? You bet. It's called a reflex, a surprise, an accident, or a mistake! We've all had the experience of stumbling, tripping, or falling due to the step or curb we didn't know was there. Your brain couldn't predict the step because it didn't get the sensory information (i.e., you didn't' see it). Your brain's ability to correct prediction errors eventually caught up as you tried to break your fall.