Ingo Titze, Associate Editor

Can I Direct My Sound Toward a Listener?

Ingo R. Titze

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When we emit sound, most of us are convinced that we can direct it to the listener. When performing on stage, we may even select a person in the audience to whom we "deliver" the song. We are taught to project, rather than to spread or diffuse our sound. There are some basic laws of acoustics that partially support and partially reject the idea that we can direct the sound we produce.

Radiation of sound from a pulsating sphere (the simplest radiator) spreads equally in all directions. The sound waves themselves are spheres. The radiation pattern is called omnidirectional, meaning that the sound field is the same in all directions. Furthermore, no preference is given to any specific frequency in the sound pattern. If our mouth were such a simple radiator, the question posed in the title would be answered unequivocally: No, I cannot direct my sound to the listener—it spreads equally in all directions, no matter how I turn in a circle as I sing.

Experience tells us, however, that we hear a louder sound when the singer is facing us than when he is turned 90° or 180° away from our line of sight. Very careful listening would reveal that not only does the sound intensity change, but the sound quality (timbre) also changes as we deviate from the axis straight out of the mouth. What physical law explains this?

All directionality in sound (other than omnidirectionality) is explained by boundary effects. Our mouth is not a pulsating sphere, but rather a pulsating air plug in an open orifice in the head. The head becomes a baffle, nearly spherical in shape. (Acoustically, a baffle is defined as any object that restrains or cancels the sound in specific directions.) As sound radiates from the mouth, our cheeks and other facial tissues baffle (redirect) the sound that would otherwise spread evenly around the mouth in all directions. Low frequency components in our sound, whose wavelengths are large in comparison to the mouth and head diameter, are not easily baffled (redirected) from a normal spherical pattern around the head (Figure 1). For example, a 100 Hz frequency component, whose wavelength is 3.5 m, spreads easily around a head baffle that has a 15 cm diameter. High frequency components, on the other hand, are baffled by the mouth and head to move in a straighter line. A 3,000 Hz frequency component (around the singer's formant cluster) has a wavelength of 11.6 cm, which is on the same order of magnitude as the head diameter.

So, how do I project my sound in a certain direction? I cannot hurl it like a projectile, but I can color it with brightness (*chiaro*). I can direct the high

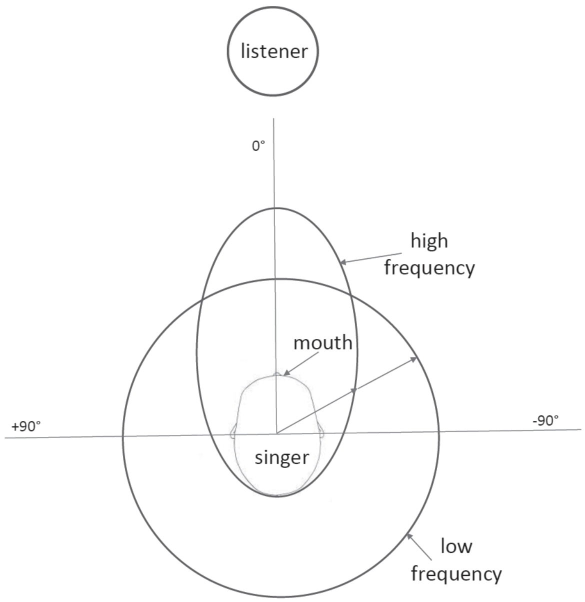

Figure 1. **Sound radiation pattern around the head of a singer. The length of an arrow from the center of the head to the circular or oval pattern is a measure of the intensity of the sound.**

frequencies to a portion of the performance space, and specifically to an individual. The low frequencies will remain undirected, however. The warmth and darkness (*oscuro*) in my voice are lost unless the performance hall directs low frequencies to the listener by reflections from the walls and ceiling. Room acousticians design performance halls such that low frequencies that "crawl" around the walls get redistributed to the listener.

When males and females are on the stage together, the males are often the losers in getting the sound to the audience. The higher frequencies produced by the females radiate better from the mouth, and they are more directed. This is one reason why the operatic ring (singer's formant cluster) is so important for male singers.

The trumpet of a prophecy! O Wind,
If Winter comes, can Spring be far behind?

from "Ode to the West Wind,"
Percy Bysshe Shelley