

Ingo Titze, Associate Editor

Singing and Calling Outdoors

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IN THE SUMMERTIME, it is delightful to hear a concert in the park or any other outdoor venue. Opera singers who pride themselves in getting sound to listeners in the back of a large opera house, 50 meters from the stage, are often surprised that their voices do not carry to those same distances outdoors. Most musical instruments are routinely amplified for outdoor performances, especially when there are no walls, tall buildings, or roof structures to take advantage of reflections.

The scientific explanation comes from the *inverse square law* in acoustics. When sound spreads out from a localized source in all directions, the wavefronts form a sphere around the source. The sound intensity is then reduced dramatically with distance from the source. The area of a sphere is $4\pi R^2$, where R is the radius of the sphere. For every doubling of distance from a localized source of sound, the sound level reduces by 6 dB. This comes from the formula

$$\Delta SPL = 10 \log_{10} (1/R^2) = 10 \log_{10} (1/2^2) = -6 \text{ dB},$$

where ΔSPL is the change in sound pressure when R is doubled and everything else remains constant. Typically, a well trained singer can produce a call or a sung tone with a sound level of 105 dB at 1 m. Based on the inverse square law, this would reduce to 99 dB at 2 m, 93 dB at 4 m, 87 dB at 8 m, 81 dB at 16 m, 75 dB at 32 m, 69 dB at 64 m, and 63 dB at 128 m. Thus, in a little more than the length of a football or soccer field, the sound level has diminished by 42 dB (Figure 1, thick line). An *ff* sound at 1 m has become a *ppp* sound at a little over 100 m. The environmental noise floor in most outdoor venues would be on the order of 40–50 dB, giving the listener a signal-to-noise ratio of only 10–20 dB.

Figure 1 also shows sound pressure level (SPL) measurements (thin lines) obtained from a singer calling words at one end of an outdoor field. The words were: *how, hi, hoy, hey, heed, food, yahoo, panpan, help, ayuda, mayday*. SPL measurements were made only at distances of 1 m, 25 m, 50 m, and 100 m, which means that the curvature of the inverse square law was not well reproduced, but the general trend is clear. Note, however, that the loss of sound level 100 m from the source was greater than predicted by the inverse square law. This may be a directionality phenomenon. Higher frequency components in the calls are more direct and may have propagated over the top of the SPL meter, which was on a tripod only 3 feet above the ground. Alternatively, it is possible that reflections or absorption by the grassy surfaces on the field may have decreased the sound level at 100 m.

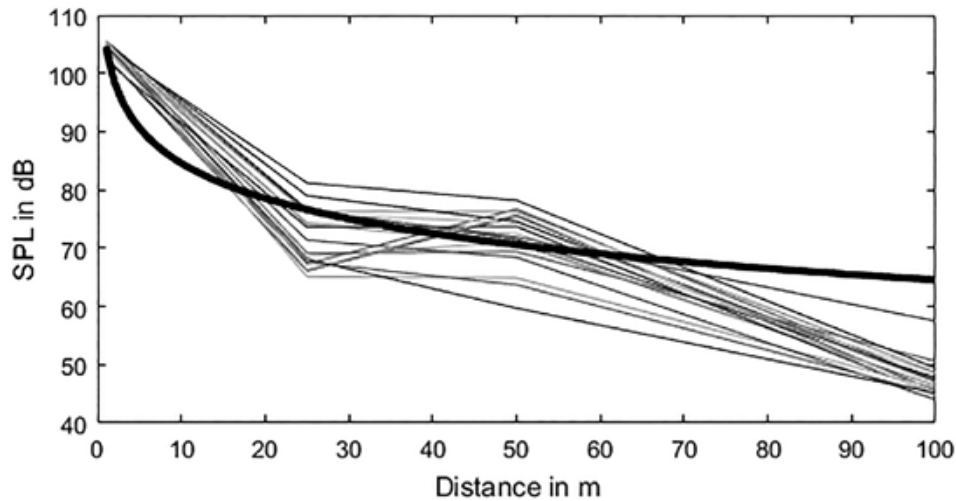


Figure 1. Sound pressure level (SPL) as a function of distance in an outdoor field. The thick line represents the inverse square law, while the thin lines represent measurements from a singer who called out words.

Performance halls are designed to capture all the sound and spread it evenly to the listeners. This spreading (diffusion) of sound is controlled by non-parallel walls and reflectors placed strategically on walls and the ceiling of the hall. Reflected sound does not get to the listener at precisely the same time as direct sound, but fraction of a second delay is usually tolerated in light of the substantially higher sound level received.

The take home message for singers is that your acoustic environment can be friend and enemy. It is worthwhile to understand room and outdoor acoustics, realizing what can be corrected at the source and by the source (you) and what requires technological assistance. You can gain 6 dB by doubling your lung pressure or by raising your pitch by an octave,¹ but that is either not possible or too high a price to pay to compensate for an unfriendly environment.

NOTE

1. Ingo R Titze, *Principles of Voice Production* (Salt Lake City: National Center for Voice and Speech 2000), Chapter 9.

Music must be paramount:
Choose for this an Uneven Rhythm,
More indefinite, more soluble to air,
With nothing to press or bind.

You must not hesitate to choose
Your words without ambiguity:
The best song is a hazy song
Where Vagueness and Precision join.

There, are eyes beautiful and veiled,
And the quivering light of high noon,
There, in a cooled autumnal sky,
Is a blue confusion of bright stars.

For we must have Nuance still,
Not Color—nothing but nuance!
Ah! only nuance can betroth
Dream to dream and flute to horn!

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