CRITICAL DISTANCE AND MUSICIANS REMAINING A SUFFICIENT DISTANCE FROM EACH OTHER

Bio: Marshall Chasin

Bio: Bill Gastmeier earned a Masters Degree in Electrical Engineering from the University of Waterloo with a specialty in Acoustics. In his early career he designed microphones and hearing aids and worked closely with the Audiological Community. He became a registered Acoustical Consulting Engineer and was a founding partner of HGC Engineering in Toronto and an Adjunct Associate Professor in the School of Architecture at the University of Waterloo.

Bio: Mead Killson

During this Covid19 pandemic we have all become concerned about the proximity of one vocalist or instrumental musician to another. It is likely these concerns will remain well into the future, especially during flu season. Increasing the distance between performers has been shown to benefit health by reduce viral spread, and as long as this increased distance does not degrade the intelligibility of singing or the quality of instrumental music. Increased distancing would also have hearing conservation benefits for those who find themselves in a noisy instrumental environment.

A concept first delineated by Sabine, and expanded on by others, is the Critical Distance. This is the physical distance where the sound arriving directly from the source would equal the reverberant or reflected sound level in the room. This distance turns out to be proportional to the volume (V) of the performance venue in cubic meters, and inversely proportional to the Reverberation Time (RT60) which is the time required for a sound to decay to 60 dB below its initial level (see Figure 1). As the RT60 is inherent in the calculation of Critical Distance it is worth reviewing some of its features.

Reverberation Time (RT60):

A comparison between a quantity of "early reflections" arriving earlier than 80 msec after the direct sound and the "later reflections" which arrive after 80 msec can be quite useful in defining the acoustics of a musical venue. (see for example, Chasin, 2016). However, for the purposes of this article we will consider the Reverberation Time (RT60) to be the time taken for the sound to be attenuated to 60 dB below its initial value once the source has stopped, which includes both early and late reflections.

The RT60 provides information about the general quality of music and speech in a room as well as information about the absorption of the walls, ceiling, and other surfaces. From Sabine we know that the "equivalent absorption surface area" A, which may be quite difficult to calculate, can be nicely estimated from the equation $A \sim V/(6*RT60)$ so all we need to know are the physical dimensions of the room (to calculate the physical Volume V) and a quick measure of its RT60 to gain information about the absorptive nature of the room surfaces.

A graph showing the calculation of the RT60 is shown in Figure 1, and while many acousticians have noted its bluntness as a predictor of sound or music quality in a room, it does provide a fairly good first estimate. One element of its bluntness is shown in Table I. Despite having similar RT60 values, one of the halls is only rated as fair to good whereas another hall is rated as being superior. Table II shows some RT60s for various rooms.

Concert Hall	**Quality**	**RT60 (seconds)**
Boston Symphony Hall	Superior	1.85
San Francisco, Davies Hall	Good	1.85
London, Barbican Large Hall	Fair to Good	1.7

Table I: Despite having similar RT60 values, the sound quality of these three halls can differ. Adapted from Hidaka et al., 1995.

Room	RT60 (seconds)
Good classroom	0.6
Echoey classroom	1.2
Underground concrete car garage	3-4

Table II: Some examples of Reverberation Times (RT60) in some rooms (for example, Chasin, 1996)

And back to Critical Distance:

The Critical Distance is greater in larger volume rooms which have lower levels of reverberation. In contrast, smaller rooms that are quite echoey have shorter Critical Distances.

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PLACE FORMULA HERE d = 0.057*square root (V/RT60)

FIGURE 2

Using the formula in Figure 2, one may obtain an approximate distance in meters, or one could actually measure it, by assessing the gradual decline and then the plateau of the sound level as a function of increasing distance in the room with a sound level meter or appropriate Smartphone app (for example Figure 3)

One feature about the formula is that the RT60 contains a factor related to the absorptive characteristics of the surfaces in the performance venue. Contributions from carpeting, acoustic tiling, seat cushions, and even the number of people in the audience (and how fat and hairy they are) are all factors in calculating the absorption of the sound energy. The RT60 includes those factors implicitly.

As an example, if we assume an arbitrary but commonly found RT60 of 1 second, in a room that `be ~ 0.057 x 27.4 = 1.56 meters or about 5 feet. If singers in a choir, or instrumental musicians were 5 feet apart they would hear each other reasonably well, and the audience would perceive good harmony and cohesion.

If the room was much larger (e.g., 25 meters x 40 meters x 10 meters), such as many churches, but with a similar RT60 of 1 second, the Critical Distance would be 5.7 meters or around 18 feet, so the singers or instrumental musicians could be located farther apart and still hear each other, and the audience could still appreciate their music.

Of course, in practice larger performance venues would have larger RT60 values higher than 1 second, so the Critical Distance would typically be less than 18 feet. At such distances of course the participants would need to pay special attention to the conductor and listen carefully to overcome the inevitable time delays and sound level reductions associated with such distances.

The first problem in attempting to space singers 10 feet apart (or 20 feet apart in one choir) was the almost universal objection from the singers that they would not be able to hear each other and blend well,

A simple demonstration calmed most of the fears: When one of the authors, Dr. Mead Killion, as choir director sang the phrase “Amazing Grace” at a high level (fff) at successive distances of 5,10, 15, etc. to 40 feet, it became apparent to most that they were *not* being misled.

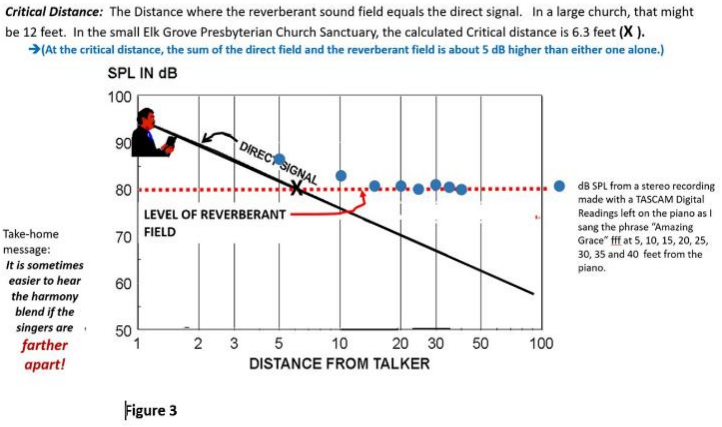

Figure 3

Although the blend was better than usual with everyone spread out, the basses said that they could not hear each other as well. One solution for the basses was to give them HearHooks™ (MCK Audio) earphones with tiny 4-way-

Figure 4. Elk Grove Presbyterian Church Christmas Cantata while spread out; a situation that will be seen more and more throughout Covid19 and in subsequent flu seasons.

(MCK Audio) earphones with tiny 4-way-wireless modules that allowed our four basses to hear each other as if sitting in a section.

The advantage of the open-ear HookHooks earphone is that the sound from the receivers is fed through a tube hooked over the ear. The open end is fitted in front of the earcanal, providing sound with a high-frequency boost. Wearers can hear people who have the other receivers, *but they also can hear sounds around them.* It decreases the cognitive effort required for processing audio input. In terms of the choir, it allowed the "bass section" to hear each other better and we suddenly had a powerful bass section! HearHooks are a product of MCK Audio, a new research and product development company founded by Dr. Mead Killion.

These are strategies that performing artists can use when public health concerns allow them to meet together while still maintaining a "healthy" distance from each other.

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Chasin, M. (1996). Musicians and the Prevention of Hearing Loss. Singular Publishing Group, Inc. San Diego, CA. ISBN 1-56593-626-4.

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Hidaka, T., Beranek, L.L., and Okano, T. (1995). Interaural cross-correlation, lateral fraction, and low- and high-frequency sound levels as measures of acoustical quality in concert halls. Journal of the Acoustical Society of America, 98(2), 988-1007.

Tiner, S (2021) Hearing and, Most Importantly, Understanding. Discovery's Edge, Mayo Clinic's Research Magazine (https://discoverysedge.mayo.edu/2020/10/13/hearing-and-most-importantly-understanding/)

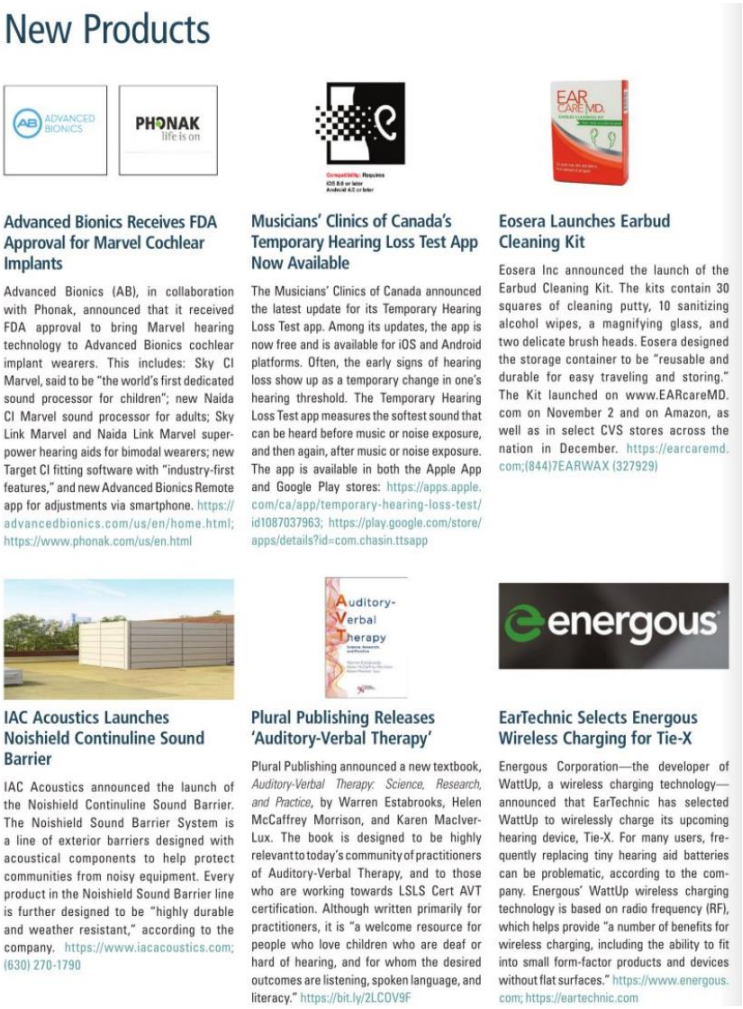
See below

Pair of ads I would like to appear /\ side by side somewhere. The picture in the right ad is a place holder. I will ask an experienced artist friend to do better, but you can use it as if necessary.

I'd like the following to be included in the New Products blurb if there is one:

For the technically curious: Companion Mics use a 2.4 HGz spread-spectrum high-fidelity packet-switching transmission that allows four wearers to hear each other clearly from up to 30 feet away.

The HearHook earphone uses a sound tube hooked over the ear that leaves the ear open.



New Products

Advanced Bionics Receives FDA Approval for Marvel Cochlear Implants

Advanced Bionics (AB), in collaboration with Phonak, announced that it received FDA approval to bring Marvel hearing technology to Advanced Bionics cochlear implant wearers. This includes: Sky CI Marvel, said to be "the world's first dedicated sound processor for children"; new Naida CI Marvel sound processor for adults; Sky Link Marvel and Naida Link Marvel super-power hearing aids for bimodal wearers; new Target CI fitting software with "industry-first features," and new Advanced Bionics Remote app for adjustments via smartphone. https://advancedbionics.com/us/en/home.html; https://www.phonak.com/us/en.html

Musicians' Clinics of Canada's Temporary Hearing Loss Test App Now Available

The Musicians' Clinics of Canada announced the latest update for its Temporary Hearing Loss Test app. Among its updates, the app is now free and is available for iOS and Android platforms. Often, the early signs of hearing loss show up as a temporary change in one's hearing threshold. The Temporary Hearing Loss Test app measures the softest sound that can be heard before music or noise exposure, and then again, after music or noise exposure. The app is available in both the Apple App and Google Play stores: https://apps.apple.com/ca/app/temporary-hearing-loss-test/id1087037963; https://play.google.com/store/apps/details?id=com.chasin.ttsapp

Eosera Launches Earbud Cleaning Kit

Eosera Inc announced the launch of the Earbud Cleaning Kit. The kits contain 30 squares of cleaning putty, 10 sanitizing alcohol wipes, a magnifying glass, and two delicate brush heads. Eosera designed the storage container to be "reusable and durable for easy traveling and storing." The Kit launched on www.EARcareMD.com on November 2 and on Amazon, as well as in select CVS stores across the nation in December. https://earcaremd.com;(844)7EARWAX (327929)

IAC Acoustics Launches Noishield Continuline Sound Barrier

IAC Acoustics announced the launch of the Noishield Continuline Sound Barrier. The Noishield Sound Barrier System is a line of exterior barriers designed with acoustical components to help protect communities from noisy equipment. Every product in the Noishield Sound Barrier line is further designed to be "highly durable and weather resistant," according to the company. https://www.iacacoustics.com; (630) 270-1790

Plural Publishing Releases 'Auditory-Verbal Therapy'

Plural Publishing announced a new textbook, *Auditory-Verbal Therapy: Science, Research, and Practice*, by Warren Estabrooks, Helen McCaffrey Morrison, and Karen MacIver-Lux. The book is designed to be highly relevant to today's community of practitioners of Auditory-Verbal Therapy, and to those who are working towards LSLS Cert AVT certification. Although written primarily for practitioners, it is "a welcome resource for people who love children who are deaf or hard of hearing, and for whom the desired outcomes are listening, spoken language, and literacy." https://bit.ly/2LCOV9F

EarTechnic Selects Energous Wireless Charging for Tie-X

Energous Corporation—the developer of WattUp, a wireless charging technology—announced that EarTechnic has selected WattUp to wirelessly charge its upcoming hearing device, Tie-X. For many users, frequently replacing tiny hearing aid batteries can be problematic, according to the company. Energous' WattUp wireless charging technology is based on radio frequency (RF), which helps provide "a number of benefits for wireless charging, including the ability to fit into small form-factor products and devices without flat surfaces." https://www.energous.com; https://eartechnic.com

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See also the 25-year-history of Companion Mics Developments, which might help on the New Products blurb

1996 Companion Mics Dream Mead C. Killion 2-1-2021

3 3/8" X 2 5/16" 1997 Companion Mics -- Dreamed for Performance Published

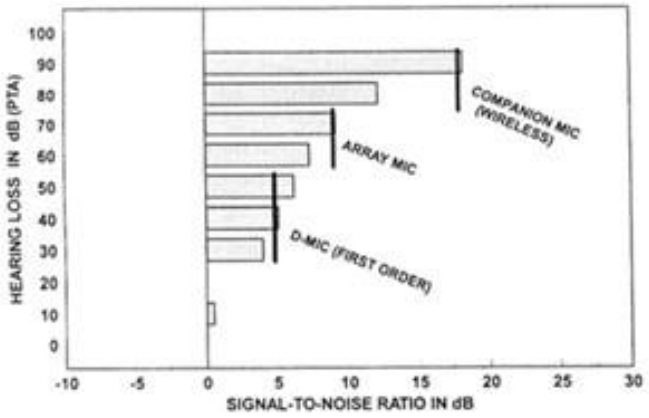

Fig. 5. Bringing people back to normal ability to hear in noisy places. Three technologies make it possible for individuals with mild to profound hearing losses to understand speech in normally noisy social situations. Killion 1997 HA Past, Present Future (BJA).

2004	First prototype CM2	8 Years after the dream
2014	First CM4 units	18 Years after the dream
2017	HearHooks	21 Years after the dream
2019	Surgical Suite	23 Years after the dream

6pac: 4 ***Listener/Talker*** units plus 2 ***Listener*** units with 6 ***HearHook*** earphones

Operating Rooom

MCK Audio, Inc. **Companion Mics[tm] and HearHooks[tm]** ***In Production***

Today 25 Years after the dream