TITLE: Recent developments regarding the 15 dB improvement in SNR in noise available from four talker noise with wireless signals provided by simple clip-on-collar Companion Mics Remote Microphones.

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ABSTRACT BODY:

Abstract (200 words): The Companion Mics® (CMICS™) by Etymotic Research, and more recently by the author' company MCK Audio, have frequently demonstrated a 10-20 dB improvement in SNR in noisy groups and restaurants for up to four talkers, each of whom wears a CMIC wireless microphone unit on the collar or held near the chin. Until recently, however, the listener would need to wear an earphone. (Experimentally, two ears listening to the same signal provide only a 2 dB advantage.) The disadvantage was that the hearing aid audiologist would have to say: "If you have trouble in noise, take off your hearing aids and put on these earphones." While waiting for the incorporation of Bluetooth circuits, two other successful alternates have been introduced. The first is an open-ear HearHook© sound tube which hooks over the ear and delivers sound near the earcanal, which is also near the microphone of a hearing aid. The second is the use of a neckloop connected to the CMIC, with the hearing aid switched to "tcoil" mode. An amplified tcoil HHearbud with built-in *hum filter* allows that use even when electrical hum interference is present.

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PRESENTER: mead c killion
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Companion Mics
Presentation

ASA, Chicago
May 8, 2023

Title: New improvements to the latest 9-year-old Companion Mics system

Mead Killion MCK Audio, Inc.

OUTLINE

0. Background: The problem

Some 1 million hearing aid wearers have such a great loss of ability to hear in noise that they can't enjoy family dinners in noisy restaurants

1. **The science behind** our understanding of the problem

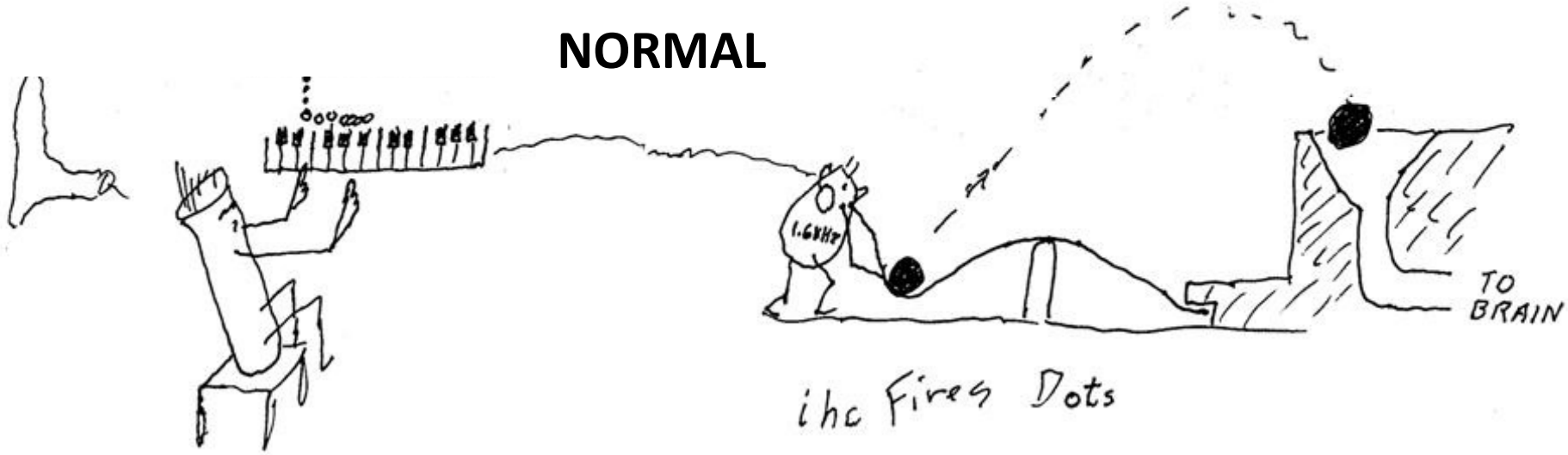
2. **The Companion Mics solution:** Four clip-on transmitting microphones each of which pick up the voice of talkers only 5-8 inches from their mouths, giving a 15 to 20+ dB increase in Signal to Noise Ratio.
   The four wearers hear each other like on a an old country party line.

3. **Marketing problems** and three trial solutions

4. **Other product innovations**

COMPLETE MODEL OF THE EAR

NORMAL



LOSS OF INNER HAIR CELLS

So many of the "audible" speech cues are lost on the way to the brain.

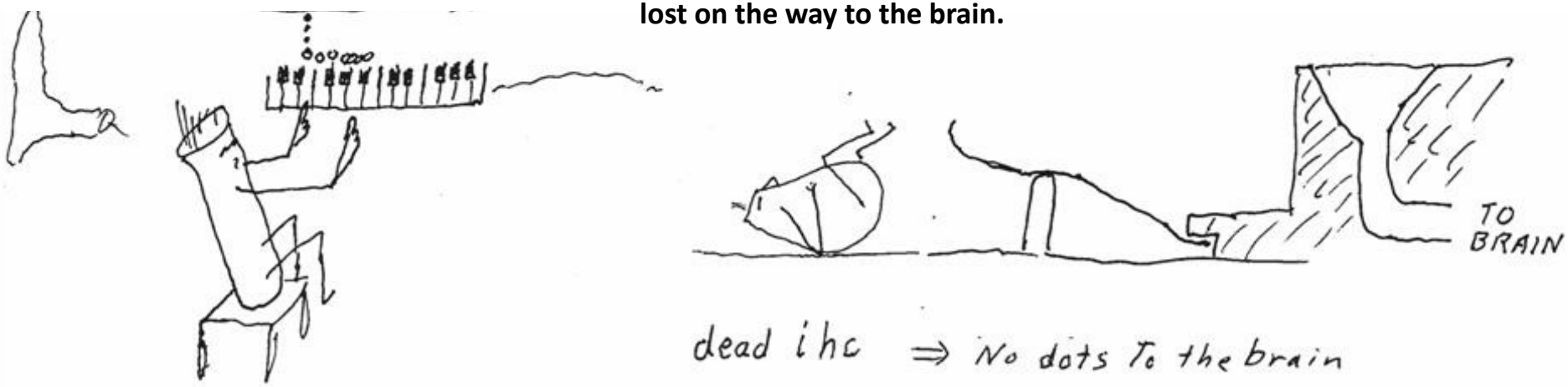
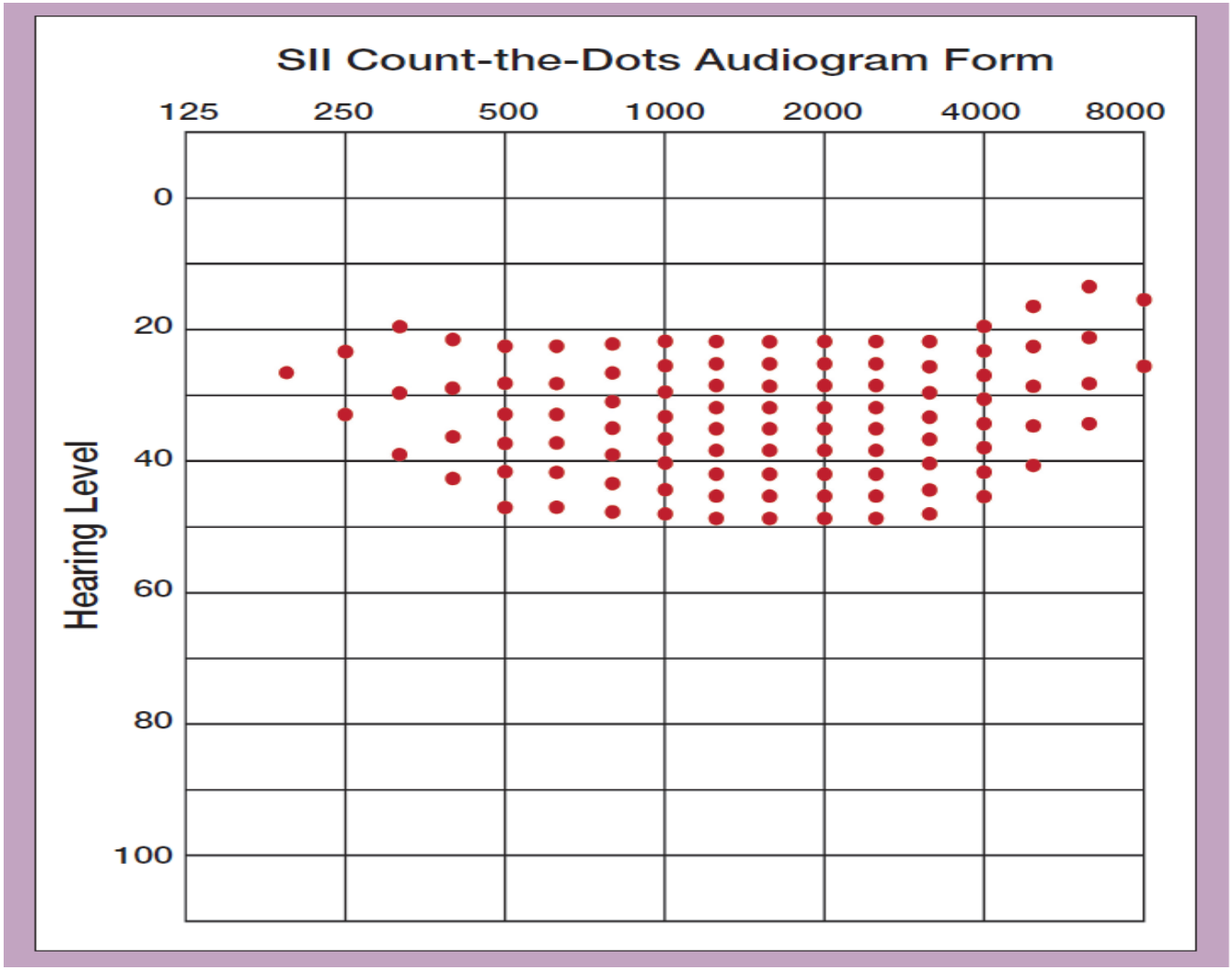
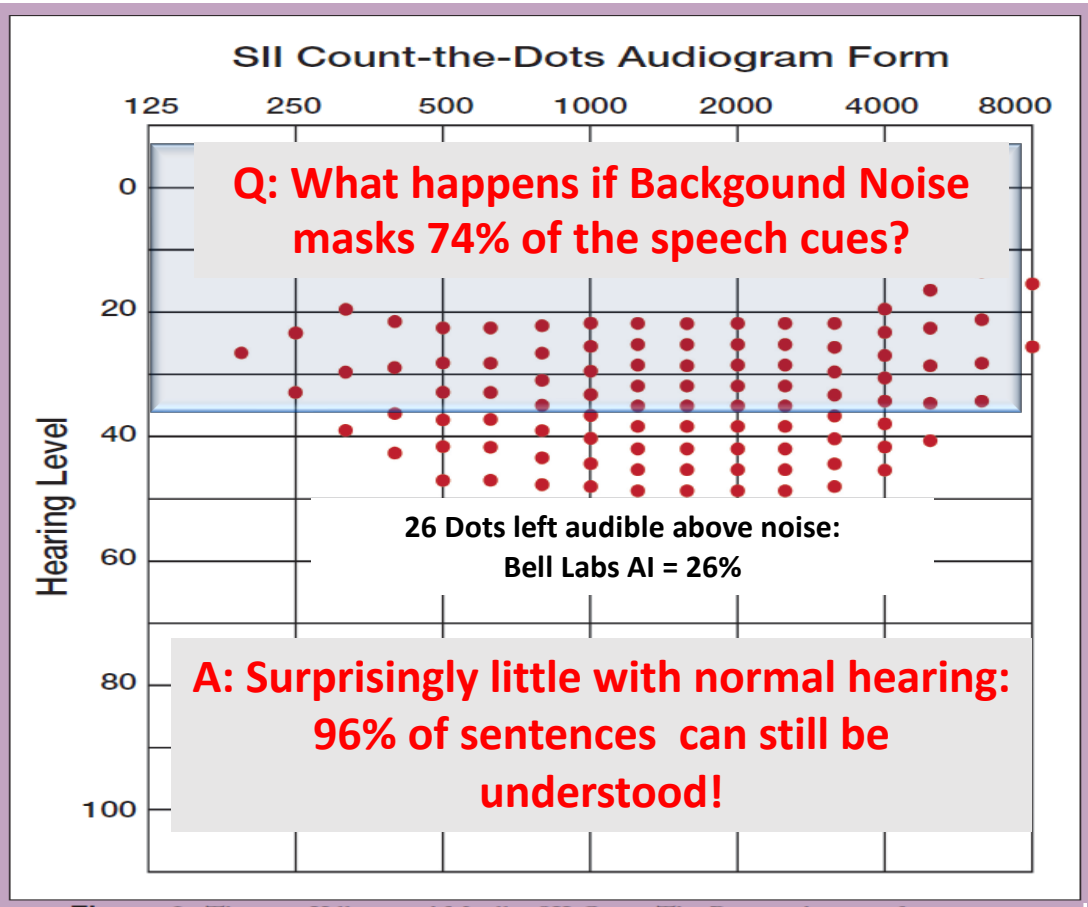


Figure 2. *The new Killion and Mueller SII Count-The-Dots audiogram for estimating the articulation index. The distribution of the 100 dots represents a speech level of 60 dB SPL (~45 dB HL).*





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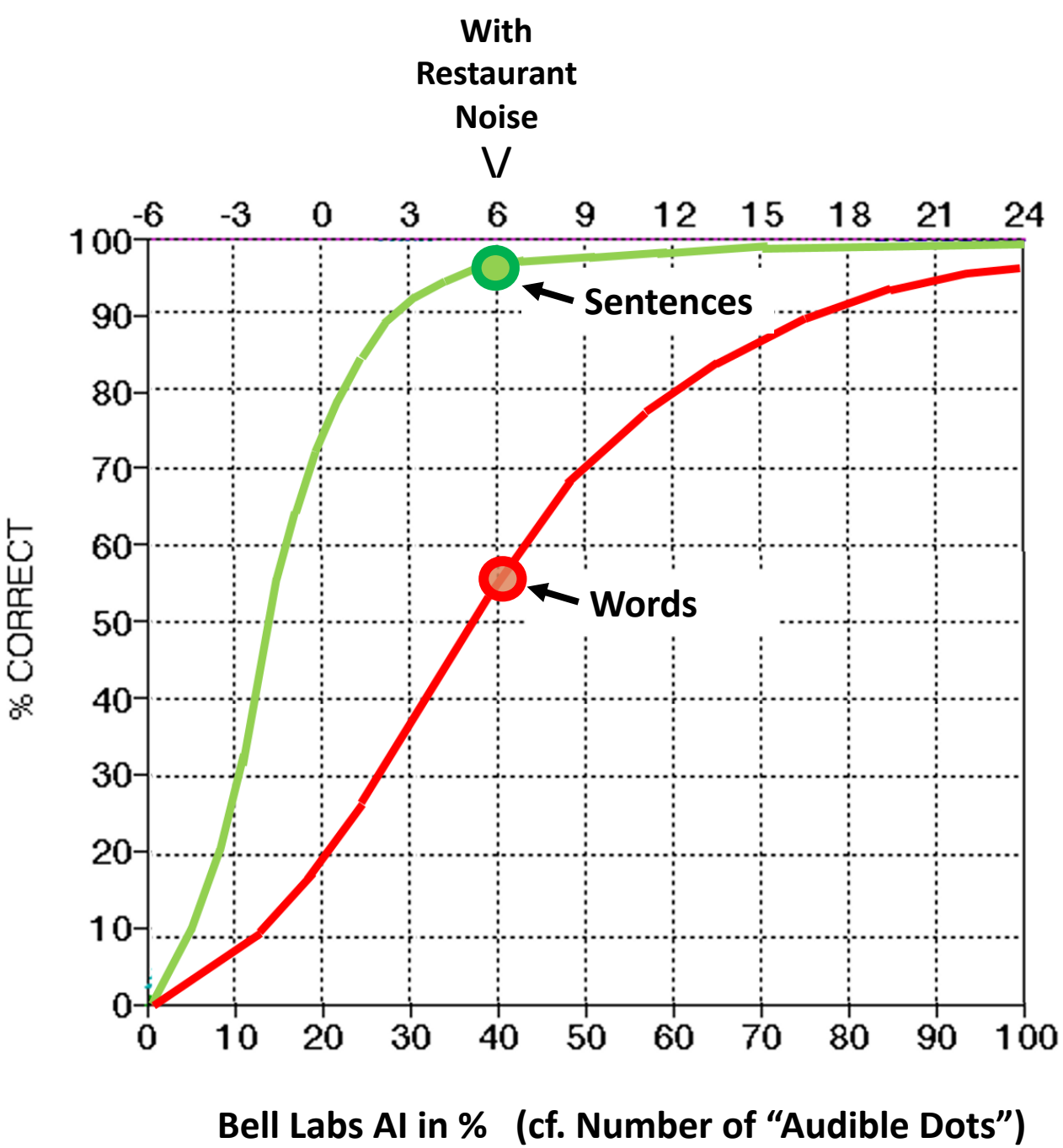
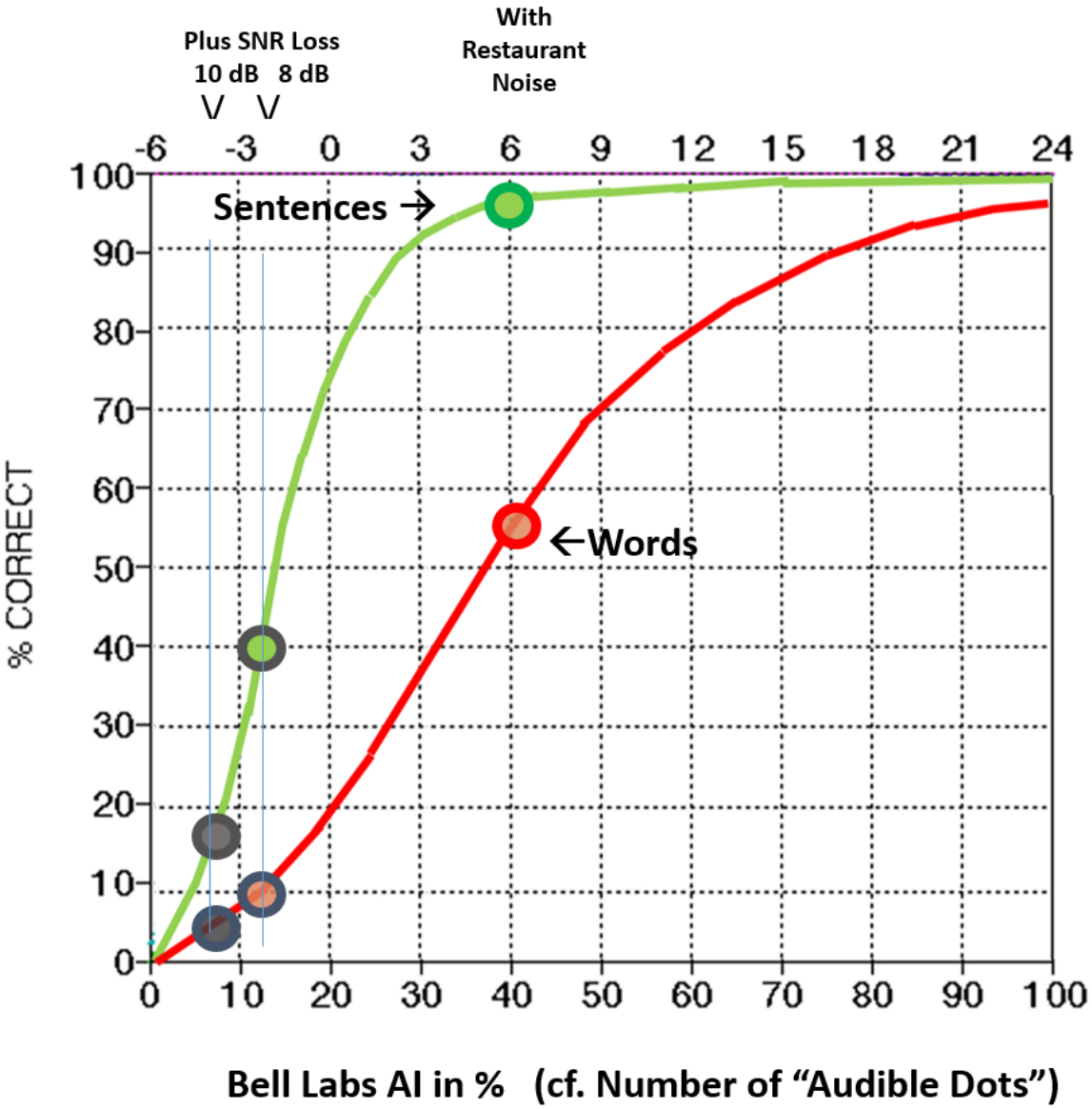

With
Restaurant
Noise
V
-6 -3 0 3 6 9 12 15 18 21 24
100 90 80 70 60 50 40 30 20 10 0
% CORRECT
Sentences
Words
0 10 20 30 40 50 60 70 80 90 100
Bell Labs AI in % (cf. Number of "Audible Dots")

But with 8 or 10 dB SNR loss, those million hearing aid wearers are excluded from conversations in moderate restaurant noise levels



History of Companion Mics® Modules and HearHook™ Earphones

1996 The Dream (After meeting Rocky Stone)

1997 The published graph:

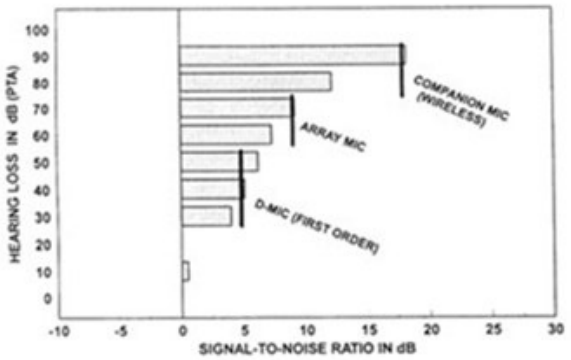


Fig 5. Bringing people back to normal ability to hear in noisy places. Three technologies make it possible for individuals with a mild to profound loss of the ability to understand speech in normally noisy situations.

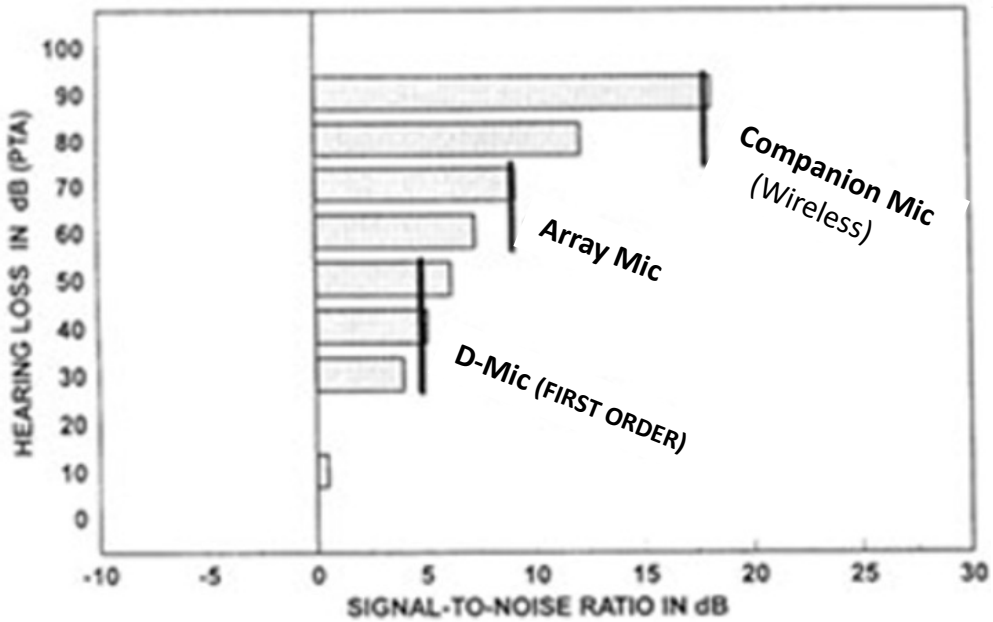
The origin of the dream I met Rocky Stone, founder of Self Help for Hard of Hearing (SHHH) at a cockail party. ***He was profoundly deaf,*** but ***he understood me at that very noisy party better than I could understand him!***

He held a microphone in his hand which he pressed against my chin. A wire up his sleeve led to his body aid. As best I can recall, that was the beginning of the dream that "Companion Mics" might allow four people to talk to each other with a 15-20 dB SNR improvement. The next year I published a paper on the possible future of hearing aids, which included the graph shown above.

The 26-year-old history of Companion Mics

1996 The Dream (After meeting Rocky Stone)

1997 The published graph:



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

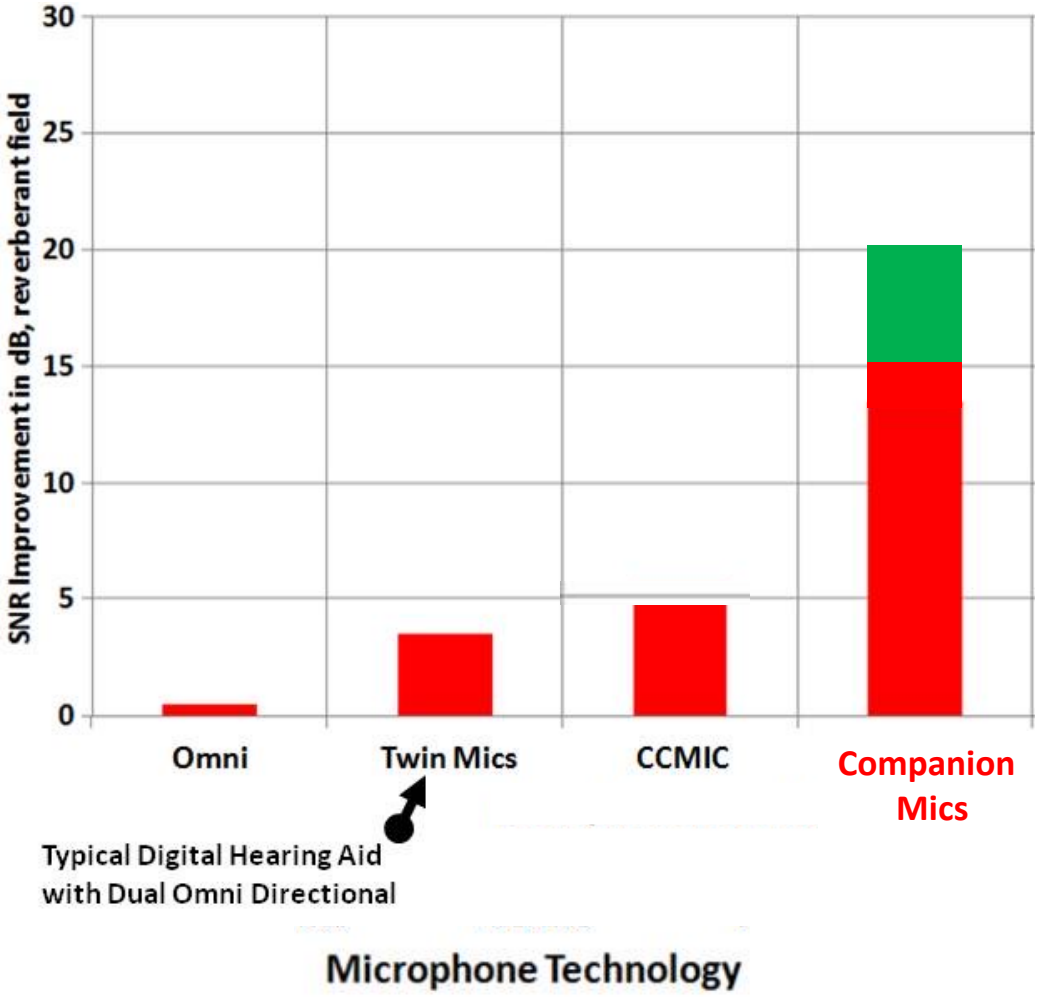
Success! Used in the five Otology Surgical Suites in Mayo Clinic Scottsdale

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

Operating Rooom

COMPARISON SUMMARY

Signal-to-noise ratio vs. Technology



← Collar 20 dB

← Shirt Clip 15 dB

Introduced in 1996

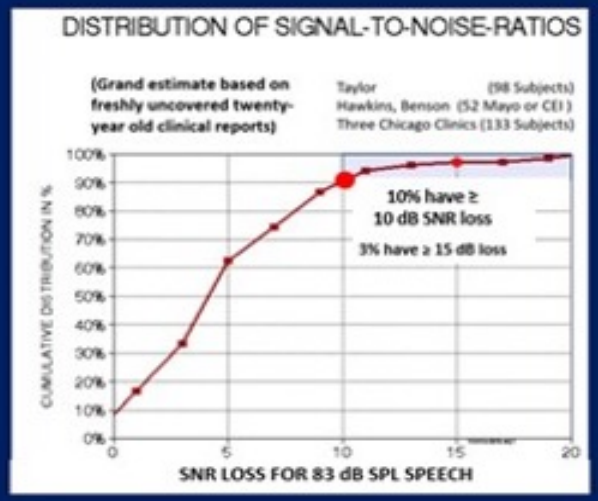
As if you friend was talking close to your ear, not across the table!

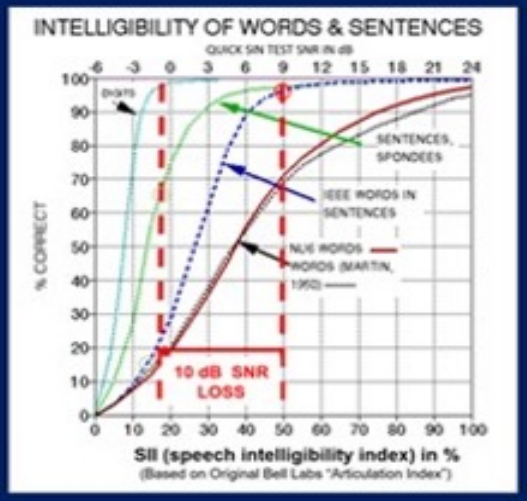
A few years later we ran a wonderful ad in HRev

November Hearing Review

We have an easy solution to the problems of hearing in noise.

CM4 Companion Mics® and HearHook™ Earphones:
Four talkers can hear each other almost noise free, even 20 feet away!





The upper right figure illustrates the difficulty someone with a 10 SNR loss will often experience in a social gathering of typically 85 dBA overall Sound Pressure Level, or because of a 1.5 Second Reverberation Time in some buildings – (Hawkins and Yacullo, 1984).

Under those circumstances, typical background noise and reverberation may make 50% of the speech cues inaudible even to those with normal hearing, but those with normal hearing will still be able to understand 98% of sentences and 97% of words in sentences.

***Someone with a 10 dB SNR loss,* on the other hand, may be able to understand only *14% of words in sentences and only* 65% of sentences.**

And those with 15 dB or greater SNR loss* will be unable to understand anything in a noisy restaurant or reverberant church.
****210,000 of the estimated 7 million hearing aid wearers.***

Sales did not cover the cost of the ad.

Perhaps a simple bar graph would have made a been better ad.

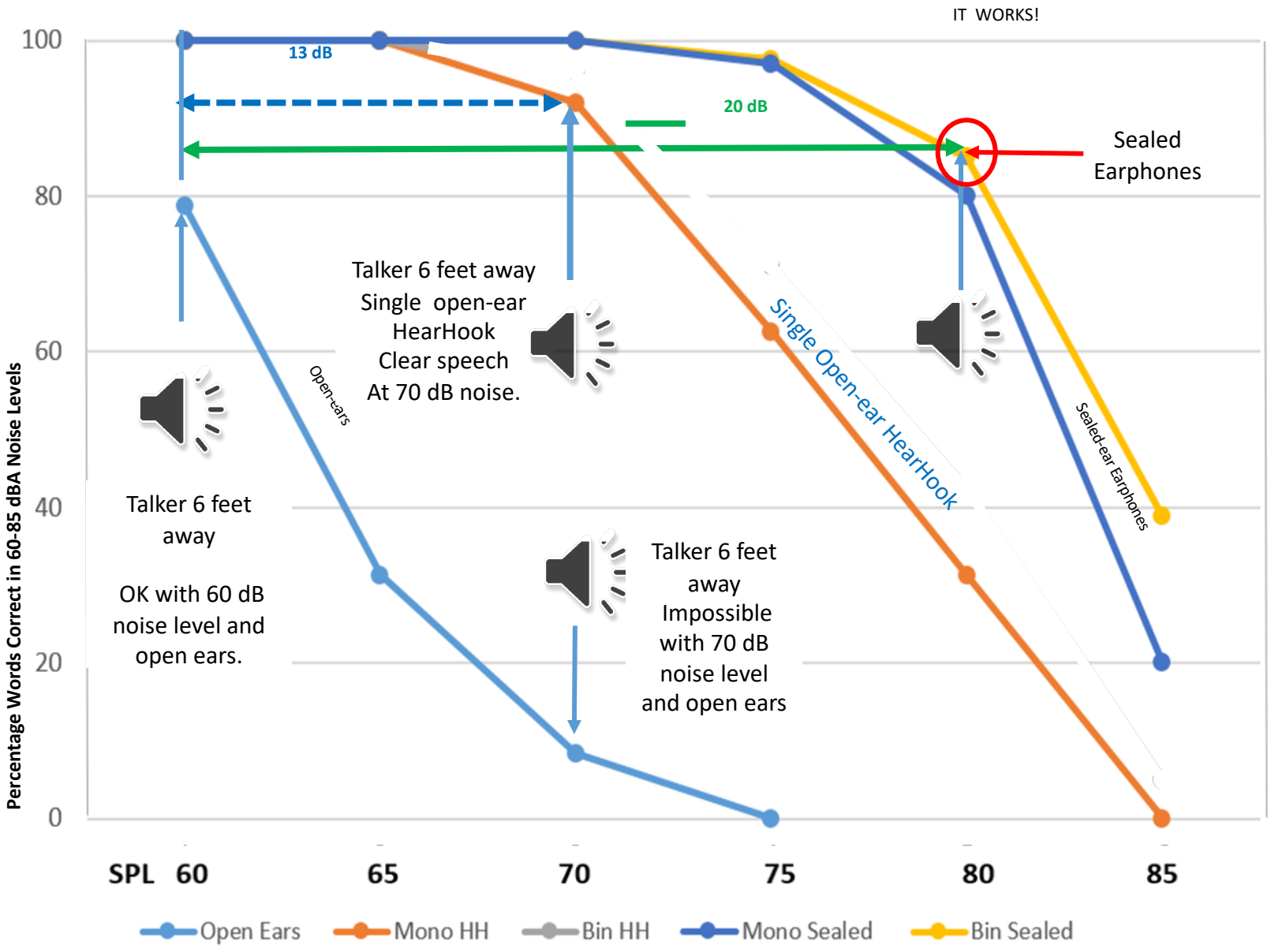
In my enthusiasm, I'm afraid that I forgot that:

"take off your hearing aids" would never be welcome advice.

In talking this over with Mayo's Mike Cevette, we almost simultaneously said: **Why don't we leave the Hearing Aids on and bring the sound to the ITE hearing aid microphone, or the open EAR,thru a simple open tube??**

The *HearHook* was born

The Companion Mics with the new **HearHook sound tube** were an immediate success in Mayo surgery.


IT WORKS!
100
80
60
40
20
0
Percentage Words Correct in 60-85 dBA Noise Levels
13 dB
20 dB
Sealed Earphones
Talker 6 feet away
Single open-ear HearHook
Clear speech
At 70 dB noise.
Open-ears
Single Open-ear HearHook
Sealed-ear Earphones
Talker 6 feet away
OK with 60 dB noise level and open ears.
Talker 6 feet away
Impossible with 70 dB noise level and open ears
SPL 60
65
70
75
80
85
Open Ears
Mono HH
Bin HH
Mono Sealed
Bin Sealed

We ran two full-page ads in ***Hearing Review***

-- BUT --

The resulting sales **still did not cover the cost of the ads.**

CM4 Companion Mics® and HearHook™ Earphones:

Four talkers can hear each other almost noise free, even 20 feet away!

Clear communication is crucial in critical situations

It can also make hiking in the mountains more fun!

Background Story by Mead Killion, PhD

Twenty five years ago, I met Rocky Stone, founder of ***Self Help for Hard of Hearing*** **(SHHH)** at an industry social hour. He was profoundly deaf, but held a microphone in his hand that he firmly pressed against my chin. A wire up his sleeve led to his body aid. He understood me in that very noisy event better than I could understand him!

The idea of moving the microphone closer to the mouth of the talker inspired the Companion Mics.

For the technically inclined

The use of a 2.4 GHZ, frequency hopping, packet switching transmission to produce practical 4-way Companion Mic units is described in detail in U.S. patents 8,019,386, 8,150,057, and 9,066,169. The HearHook earphones are described in U.S. Patents 10,306,375 and 10,560,786.

HearHook™ earphones provide improved speech intelligibility while leaving the ears open

And provide a clearer input to hearing aid microphones

Optional in-ear earphones offer clear speech even in 95 dBA SPL noise

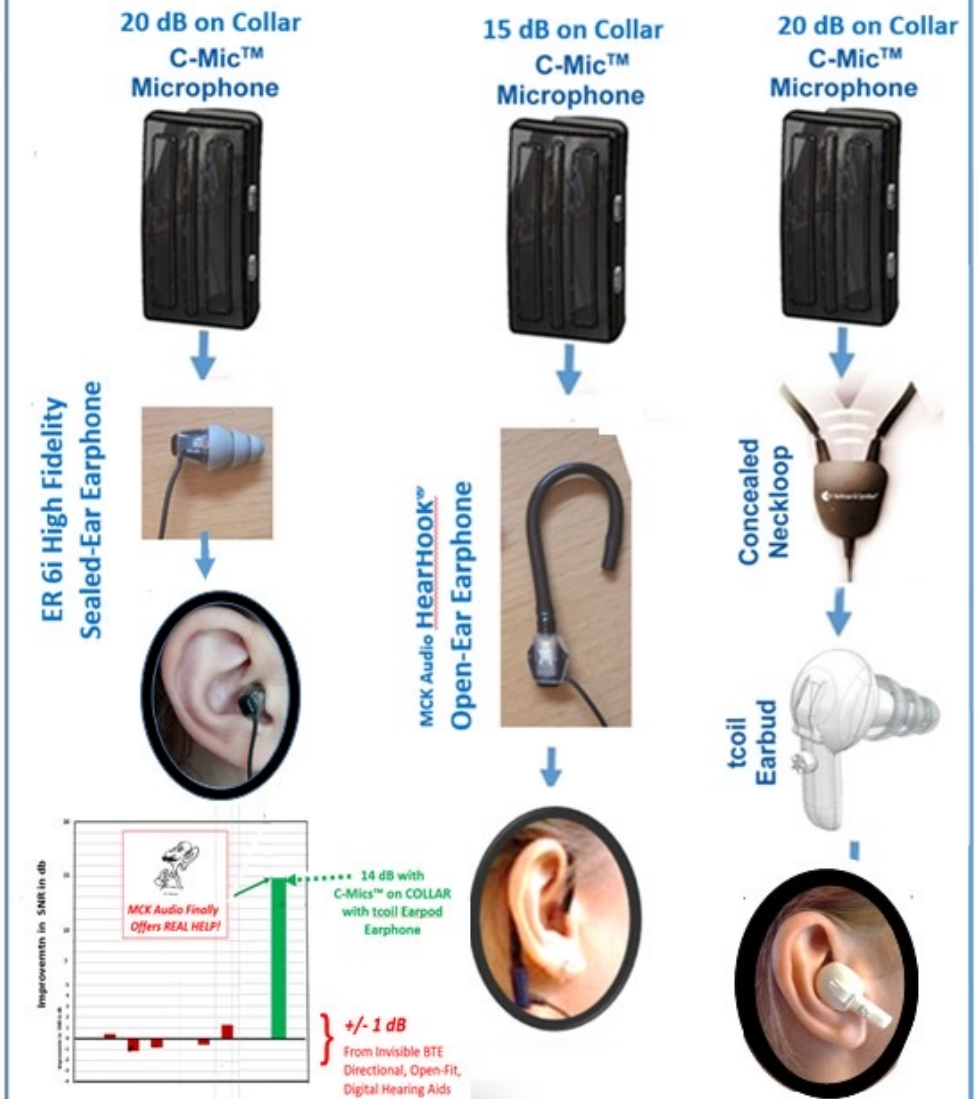
So we pursued other, less expensive, approaches.

MCK Audio's Companion Mics®

With 3 listening Options

*When loud noise has dropped intelligibility to 15%, a 10-15 dB decrease in noise can bring it back to 95-98% [Webster, 1979; Mueller and Killion, 1990].

The three systems below can decrease the relative noise by 15 to 20 dB!



Even though Etymotic Research was a much larger company back then, with literally 45 successful innovative products families since 1953 (even a portable noise dosimeter)

--- we were ***not*** successful with the Companion Mics in reaching even a small fraction of the 700,000 hearing aid wearers who have greater than SNR loss in the U.S.

I have recently been reminded that three of our my most successful previous products took 11, 20, and 25 years to bring to market! I budgeted for 2-3 years.

ETYMOTIC RESEARCH INC.

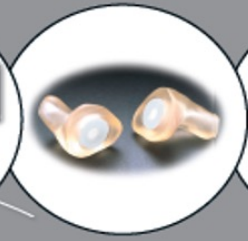
30 Years of Innovation

1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Etymotic Research® established	Response-modifying BTE earhooks	[illegible] microphone for real-ear measurement	ER-8 (K-BASS™) hearing aid	ER-12-4 "cookie-bite" earhook	ER-15 Musicians Earplugs™	ISO-AMP™ for ABR	Generic BTE earmold kit	ER-4B® and ER-4S® Canalphones	ER-10A Lo-Noise™ microphone	SIN Test™ Speech-in-Noise Test	ER-4P® MicroPro™ earphones	FIG6™ for Windows®	Variable-compression circuit die	insert earphones for MRI	ER-29 K-AMP hybrid

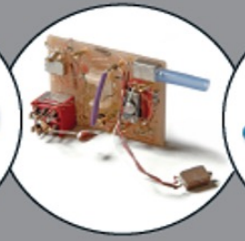
1984
ER-1® and ER-2® Insert earphones for research

1985
ER-3A® Insert earphones for audiometry and ABR

1985
ER-7C instrumentation for real ear measurement



1988
ER-15 Musicians Earplugs™



1989
K-AMP® circuitry for hearing aids

1990
ER-20® High-Fidelity Earplugs

1991
ER-4 Noise-isolating, high-fidelity insert earphones for in-ear monitoring

1998
ERO-SCAN®

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ER-9 Musicians Earplugs™	Low-cost acoustic damper for ER-20®	Special K-AMP® circuit for Songbird® disposable aid	Electronic damping circuit	ER-10A 3-Port Lo-Noise™ microphone	SBIR grant for Companion Mics® development	Low-cost compressor chip in full production	small ears ER-200 Dosimeter	GX-400™ Gaming Headset	earphones QSA Quiet Sound Amplifier®	mc5™ earphones with ACCU-Chamber® technology	headset hf3™ Made-for-Apple® headset	GunSport-PRO® Electronic Earplugs HD15® Electronic Earplugs	Made-for-Apple® headset Music-PRO® Electronic Earplugs	QSA Quiet Sound Amplifier® – BEAN™ Home Hearing Test

2005
Companion Mics®

2006
ety8™ Bluetooth® noise-canceling headset

2009
EB15® Electronic BlastPLG® Earplugs for military

2010
ER-200D Data-logging Dosimeter

2011
ETY-Kids® Safe-Listening Earphones for children

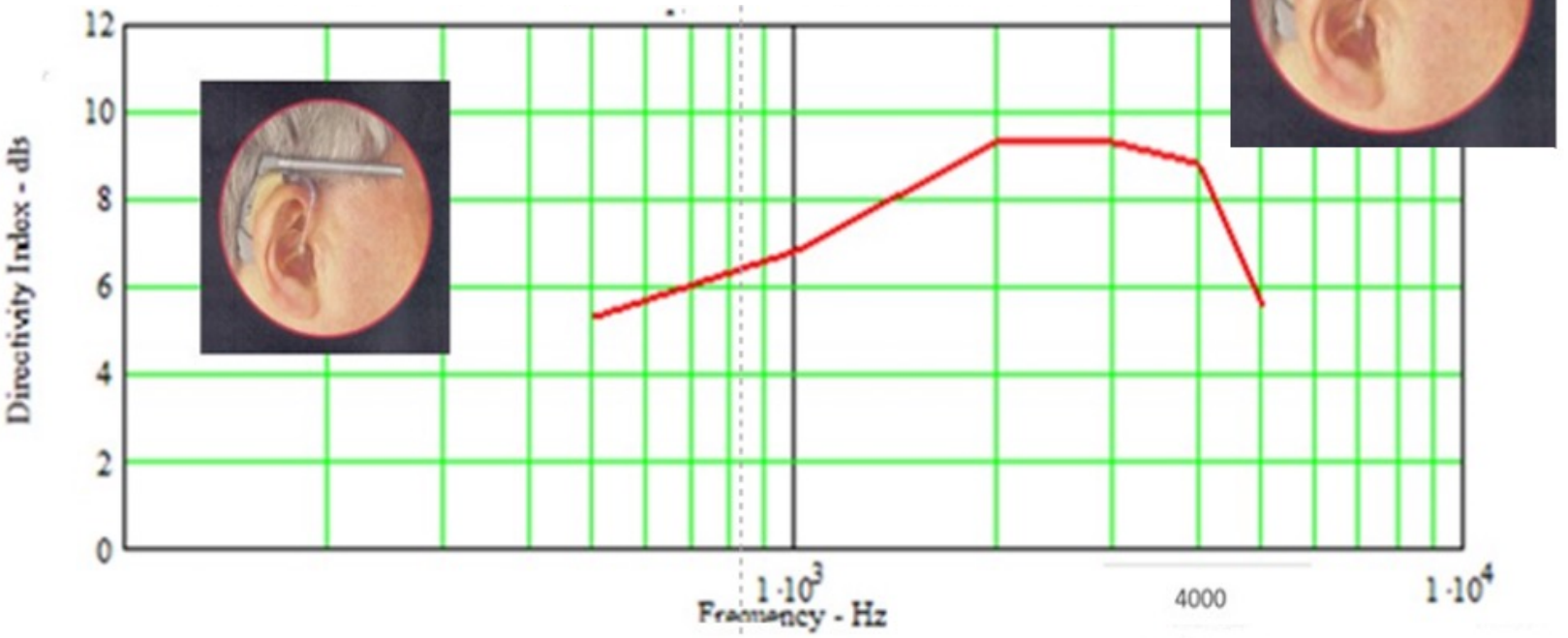
2012
ERO-SCAN Pro® with acoustic reflex

2013
ERO-SCAN® Express

2013
GSI CortiQAE Instrument

2013
Quiet Sound Amplifier® BEAN® personal sound amplifier

Finally, we have recently retooled the "Link-it" Array Mics, originally developed by Wim Soede and Roland Horsten 20 years ago. They still the best we SNR increase we know of: 8+ dB for speech, and held out in front it can be 12-13 dB!



Point at a table in a noisy restaurant, you can hear them clearly
Point to another, and that one disappears and the new one is clearly heard.

An Astrophysicist friend who has several hearing aids and remote mics, said "WOW" when he heard this one.

He keeps calling to see how we are coming with it.

The 4000 Hz polar plot correlates with the subjective impression.

"We keep trying, but we need more than what I and three part-time engineers can do!" (dr abonso)

Suspicious Consumer

Dr. Abonso

We keep trying, but we need more than Dr Abonso and three great part-time engineers can do!