

[ Text as of 29 January ]

Good morning! This is my 22nd NHCA Annual Conference, but it's been many years since I've addressed you all.

Thank you for the opportunity.

I'm really appreciative of this chance to talk to you about something for which I feel great passion. I hope that it taps into your passion for hearing as well. It's a topic that is current, touching on large trends in technology and society. Yet, at the same time, it's grounded in who we are, as human beings.

I should acknowledge the contribution of three friends and thought partners – often sparring partners. One is Ken Jacob, an engineer, long-time Bose employee and now our Chief Brand Officer. The others are Andy Sabin and Dianne Van Tasell, both instrumental in our work toward improving access to hearing assistance and hearing aids.

Let me start by simply stating my thesis.



Hearing is our most important human sense.

**Hearing is our most important human sense.**

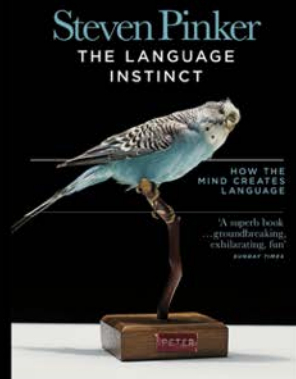
However, today we live in an age that is visually dominated, screens everywhere and so often at our fingertips. These devices and the infrastructure behind them tremendously empower us with access to information and to each other. Unfortunately, mounting evidence says that this technology, and design choices built on it, has overwhelmed our cognitive capacity to use it wisely.

But, I believe that we're entering a new era where hearing and its companion speech, augmented by technology and design that puts human experience first, can help us restore a balance that's been lost. Using our ears and voices, complementing our eyes and thumbs, we can find a way to better master the complex physical plus digital world we live in. And because of this we'll be able to do more, and we'll enjoy more of what we do.

To support this, let me turn first to the importance of hearing and speech, as described by the words of psychologists and neuroscientists.



Many thousands of years ago, our distant ancestors gathered around campfires to share stories and transfer knowledge. We still enjoy this today. So much of what humanity has achieved has resulted from people coming together in community to achieve shared goals. And, community starts with communication. But, while communication can be visual – writing or drawing – it started with spoken language.



"In any natural history of the human species, language would stand out as the preeminent trait. Simply by making noises with our mouths, we can reliably cause precise new combinations of ideas to arise in each other's minds. Language is so tightly woven into human experience that it is scarcely possible to imagine life without it, and the ability comes so naturally that we're apt to forget what a miracle it is."

*Steven Pinker,  
Harvard University*

Steven Pinker, professor of psychology at Harvard and formerly of cognitive science at MIT, has written that:

"In any natural history of the human species, language would stand out as the preeminent trait. Simply by making noises with our mouths, we can reliably cause precise new combinations of ideas to arise in each other's minds. Language is so tightly woven into human experience that it is scarcely possible to imagine life without it, and the ability comes so naturally that we're apt to forget what a miracle it is."



"Language is the primary means by which we exchange our minds. We talk to each other about the past and make plans about the future. We read and tell each other what is on our minds. We reason and solve problems collectively. We build social narratives that explain the world around us. We teach, and we learn from each other. And we argue about what is right and wrong."

*Thomas Suddendorf,  
University of Queensland*

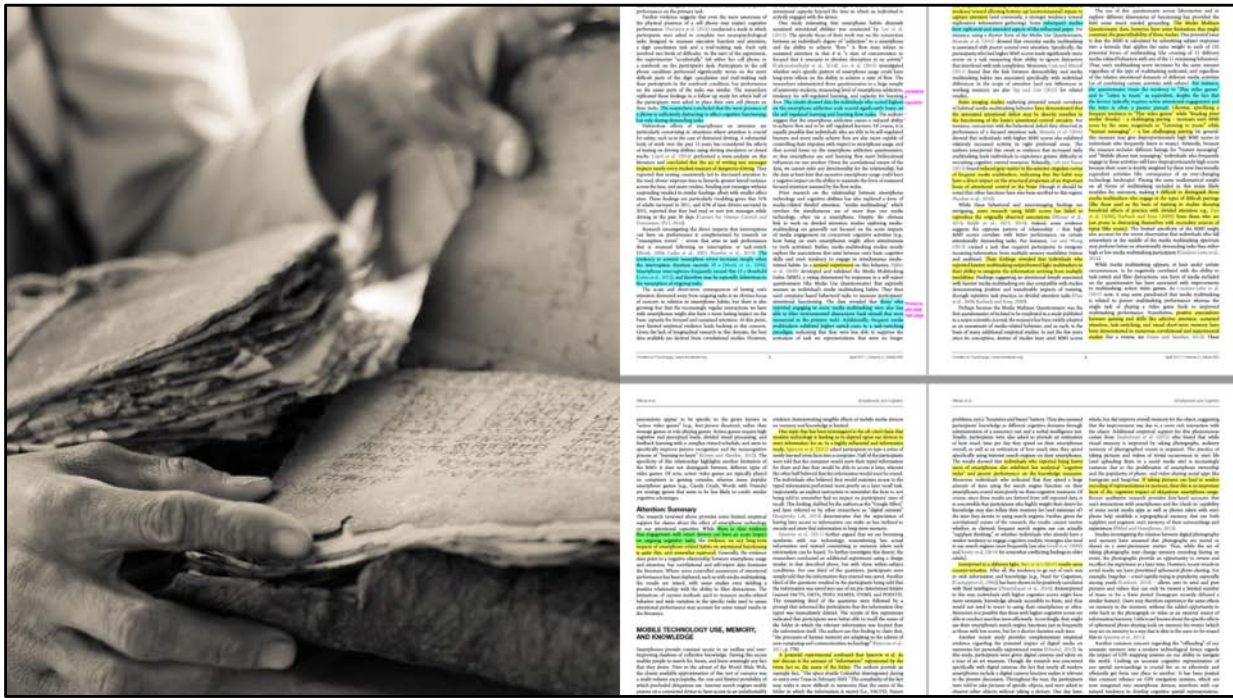
Another professor of psychology, Thomas Suddendorf of the University of Queensland in Australia, has written:

"Language is the primary means by which we exchange our minds. We talk to each other about the past and make plans about the future. We read and tell each other what is on our minds. We reason and solve problems collectively. We build social narratives that explain the world around us. We teach, and we learn from each other. And we argue about what is right and wrong."

“Language is the mechanism by which the aggregated knowledge of human cultures is transmitted. **We are because we can talk.**”

*Philip Lieberman  
Brown University*

And Philip Lieberman, a cognitive scientist at Brown University, sums it up this way:  
“Language is the mechanism by which the aggregated knowledge of human cultures is transmitted. We are because we can talk.”



We are because we can talk. Language started as sounds in air but, in time, it also was translated to symbols and written down. Written language has advantages: it's more easily absorbed at your own pace, retracing lines of thought that were at first unclear. It can more easily be skimmed, looking for that idea you remember seeing and perhaps highlighted at some point in the past. But the spoken word has on its side the power of poetry and nuance, of conveying emotion beyond what the written word can do – particularly when reduced to brevity of a tweet.

"The problems of deafness are deeper and more complex, if not more important, than those of blindness. Deafness is a much worse misfortune. For it means the loss of the most vital stimulus — the sound of the voice that brings language, sets thoughts astir, and keeps us in the intellectual company of man."

*Helen Keller,  
Letter, 1910*

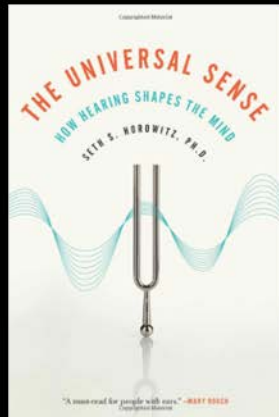
It is this ability to carry nuance, to create human connection, that perhaps led Helen Keller to write in a letter "The problems of deafness are deeper and more complex, if not more important, than those of blindness. Deafness is a much worse misfortune. For it means the loss of the most vital stimulus — the sound of the voice that brings language, sets thoughts astir, and keeps us in the intellectual company of man."



Hearing is our most important human sense.

It is this emotional connection aspect that leads me to elevate hearing to the role of most important HUMAN sense.

To illustrate this, let's do what Einstein called a *gedanken* experiment. Imagine that you're separated by an ocean from the one person in the world that you most love. You have an hour to connect with them, but you must choose between high-def video with no sound, or a high-fidelity audio connection but no picture. Which would you choose? I've asked this question of many groups and the only time someone has said they'd opt for the visual is if one of the two people is deaf. Or perhaps an infant.

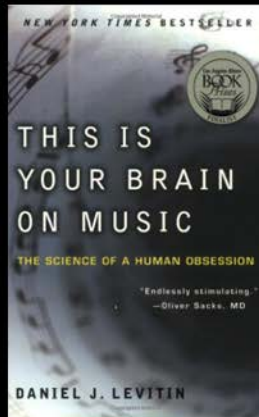


"Everything that you perceive with your ears is coloring every other perception you have and every conscious thought that you have. Sound gets in so fast that it modifies all other input and sets the stage for it."

*Seth Horowitz,  
Brown University,  
2015 NPR interview*

And, it's not just speech that touches us deeply and emotionally. It's sound itself.

A few years ago I heard an NPR interview with a neuroscientist, also at Brown. He said that "Everything that you perceive with your ears is coloring every other perception you have and every conscious thought that you have. Sound gets in so fast that it modifies all other input and sets the stage for it."



"...the emotions we experience in response to music involve structures deep in the primitive, reptilian regions of the cerebellar vermis and the amygdala – the heart of emotional processing in the cortex."

"Part of the reason we remember songs from our teenage years is because those years were times of self-discovery, and as a consequence, they were emotionally charged; in general, we tend to remember things that have an emotional component because our amygdala and neurotransmitters act in concert to 'tag' the memories as something important."

*Daniel Levitin,  
McGill University*

This is perhaps what makes music so powerful. Another neuroscientist, Daniel Levitin of McGill, wrote in his book [This Is Your Brain on Music](#):

"...the emotions we experience in response to music involve structures deep in the primitive, reptilian regions of the brain – the heart of emotional processing."

"Part of the reason we remember songs from our teenage years is because those years were times of self-discovery, and as a consequence, they were emotionally charged; in general, we tend to remember things that have an emotional component because our amygdala and neurotransmitters act in concert to 'tag' the memories as something important."



Let me tell you a story. Many years ago, a friend at Bose who had worked on music discovery showed me an interface he'd mocked up. He asked me what year I was born: 1957; he keyed it in to his laptop. Up popped a 5x5 grid of album covers. Many were from my teenage years; as Levitin said: "times of self-discovery". He then had me pick three which led to a new 5x5 grid. More were interesting, ones I owned or remembered. He had me pick three more from that grid and the next grid was amazing! I owned 70-80% of them. And I had this incredibly powerful desire to leave work, drive home, and dig out and listen to several vinyl disks of obscure English prog rock from the early 70s that I hadn't listened to in decades.

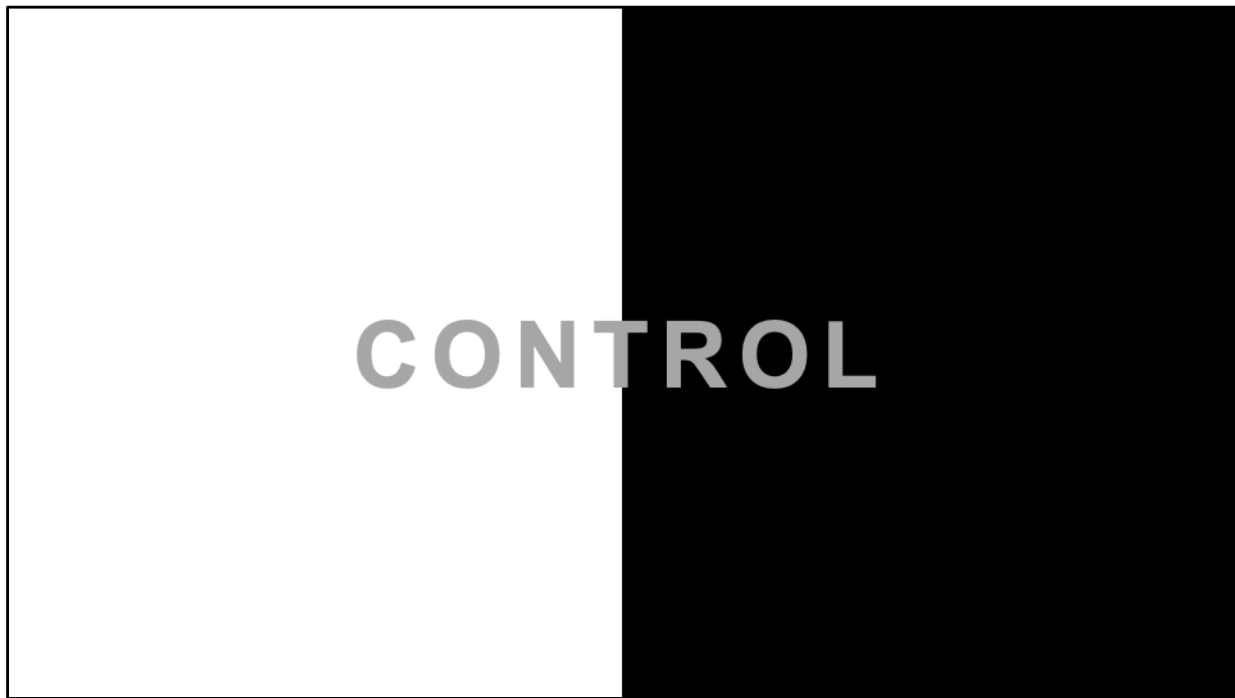
The right music can grab us emotionally, taking root deep inside our minds for the rest of our lives. It can bring us joy, it can comfort us, it can be cathartic.

Koss SP-3  
First stereo headphones  
1958



This is perhaps what led to the first stereo headphones, starting with Koss 61 years ago. The ability to totally immerse yourself in music you love, oblivious to the voices of your siblings or parents or dorm roommates, is powerful. That's certainly how I spent many hours during my high school and college years. I had Koss in high school; in college I'd moved up to some AKG K240s.

And this brings me to my next point about hearing. Why headphones matter to people.



We do not have control over our hearing to the extent that we do over our vision.

We don't have earlids, and acoustic reflex aside, we can't squint our ears when it gets loud like we can squint our eyes when it gets bright.

Yes, there's the cocktail party effect, but our ability to pull a voice out of a noisy room is not as effective as our ability to fix on an object, ignoring visual clutter.

Yes, technology to augment ears – from hearing protectors to hearing aids – exists, but the range of eye augmenters used by typical consumers is greater...



– sunglasses, reading glasses, prescription lenses, contacts, binoculars. Their use is much more common and accepted without any hint of stigma associated with, say, hearing aids. Glasses are even fashionable.

This imbalance of technology availability to augment our hearing versus our vision is changing though; more on that in a bit.

“...the uncontrollability of sound rather than its intensity that makes it stressful.”

Evans & Johnson  
*J. Applied Psychology*  
2000

#### Stress and Open-Office Noise

Gary W. Evans and Dana Johnson  
Cornell University

Forty female clerical workers were randomly assigned to a control condition or to 3-hr exposure to low-intensity noise designed to simulate typical open-office noise levels. The simulated open-office noise elevated workers' urinary epinephrine levels, but not their norepinephrine or cortisol levels, and it produced behavioral aftereffects (fewer attempts at unsolvable puzzles) indicative of motivational deficits. Participants were also less likely to make ergonomic, postural adjustments in their computer work station while working under noisy, relative to quiet, conditions. Postural invariance is a risk factor for musculoskeletal disorder. Although participants in the noise condition perceived their work setting as significantly noisier than those working under quiet conditions did, the groups did not differ in perceived stress. Potential health consequences of long-term exposure to low-intensity office noise are discussed.

3 hours low  
intensity office  
noise (55 dBA avg)  
→ increased  
stress  
→ hormones  
→ fewer attempts  
at unsolvable  
puzzles  
→ fewer  
postural  
adjustments

Let's talk about our ability to ignore auditory clutter.

I'm not talking about noise that is hearing damaging, just unwanted sound – noise – that is annoying or perhaps a bit uncomfortable. Studies have shown that noise leads to an increase in various physiological indicators of stress.

Evans & Johnson, in a study published in 2000, looked at how noise in open-plan offices affected workers. One aspect of their experiment that I found interesting involved giving subjects puzzles to solve. They were told that if they couldn't solve some, they could set them aside and go onto the next one. Some of the puzzles used had no solution; the measure was how long people persisted. What the study found was that background-level office noise, 55 dBA on average, lessened subject persistence on these unsolvable puzzles.

Later in that paper, based on the various factors in their experiments and a survey of the literature, these authors concluded that it's “the uncontrollability of sound rather than its intensity that makes it stressful.”

Have you ever experienced this?





You're trying to concentrate, or just go about your day, and some sound in your environment – people talking, a TV you don't want to watch, a song you don't like, the distant barking of a dog – pulls you away from what you were doing. You can't ignore it and you can't focus on what you want.

Of course, that same sound, say that song or TV, may be delightful to someone else.

Sound is like this dandelion. To some, it's an ingredient to a homemade wine or a source of bitter greens. To others, it's a weed to be pulled up or eradicated. Whether that sound is noise, or not, is in the ear of the ... beholder? Or should I make up the word, be-hearer?

Sony Walkman  
Portable music  
1979



iPod.  
1,000 songs in your pocket.

When headphones left the home, with the arrival of the Walkman, people suddenly had a new tool for creating the soundscape they wanted. The noise of the city could be colored or masked by music of their own choosing. They could try to drown out what they didn't want to hear. The convenience of the iPod, of having more than a cassette or CDs worth of music, made this increasingly prevalent.



Today, roam city streets and public places and you'll find headphones around or in the ears of many, many people. Zoom in on this picture and you'll likely see many heads decked out with headphones or earbuds.



Now, those of us who care about the longevity and well-being of hair cells may not like the fact that so many people blast away urban noise with even louder music. Whether it's hip hop or heavy metal, they crush unwanted sonic dandelions around them. We make not like this, but I'll argue that it's a natural human thing to do. Sound is emotion. Noise you don't want is stressful; why not wash it away with music or podcasts that you'd rather hear?

At least with a good noise cancelling headphone from a few reputable makers or, if you prefer, a well-sealing sound isolating earbud you can be in your sonic bubble without having to listen dangerously loud.

**Think of it as a noise barrier for the world around you.** Whether you're seated by the engine exit on airplanes, some of the city bustle in the office or the blast of neighborhood yard work, this headset lets you hush them all. And it does it with the flick of a switch. You never disturb musical sources in places where you couldn't before. And when you're not listening to music, we can use it to quietly enjoy a little peace. Clearly, the Bose QuietComfort headset is no ordinary headset. It's an innovation in any of these things you have to experience to believe.

**Reduce noise with Bose technology.** What, Earth describes this headset as "perfectly wonderful," especially when you "need to listen anywhere there are a lot of background distractions." That's because the QuietComfort headset actively monitors and counteracts unwanted noise and reduces it before it reaches your ears. It recognizes what you're about to hear and compares it with what you want to hear — music, or silence itself. Patented Bose technology then counteracts the noise and delivers the sound you want. *U.S. News & World Report* calls this headset "revolutionary." Respected columnist Rich Warren lists it as his "product of the year." *Sound & Vision* reports that it "can be a terrific antidote for delayed flights, engine noise, crinkly airline headphones, and all the other noisier passenger annoyances."

**Enjoy your music with Bose sound quality.** The QuietComfort headset arrives ready to use with your portable CD/MP3 player, home stereo, laptop or office computer and in-flight entertainment systems. As *Men's Journal* reports, it "puts the wearer in a state of blessed quiet, then fills the ears with rich stereo sound." The *Boston Globe* calls the audio quality "superb." Travel expert Rudy Moss finds it "stunning." Just what you expect from the most respected name in sound.

**So comfortable, you may forget you're wearing it.** With a weight of only 7.4 ounces, the QuietComfort headset nestles lightly around your ears. Audio critic Mark Plonchance calls it "the most comfortable full-sized pair of headphones I've ever used" with the "softest cupbuds I've encountered in 30 years of wearing headphones."

**By the QuietComfort headset for yourself risk free.** We don't expect you to take our word for how dramatically this headset reduces noise, how great it sounds and how comfortable it feels. You really must experience it to believe it. Call toll free to try the QuietComfort headset for 30 days in your home, at the office or on your next trip — satisfaction guaranteed. Use it to think, work and relax in peace. Listen to music or an in-flight movie with its clear, rich sound. If you love this headset, keep it. If you can hear to part with it, simply return it for a full refund of the purchase price. No questions asked.

**Call 1-800-600-2073, ext. Q1786 today.** This headset is available directly from Bose, and [Bose.com](http://Bose.com) reports that "you will not regret one penny spent" on it. You can also take advantage of our installment plan and make 12 interest-free monthly payments.\* Order your QuietComfort headset now and get a complimentary flight certificate. When you buy a qualifying ticket, your company's affiliation is free.\*\* Call today to enjoy a very different kind of headset — the Bose QuietComfort headset.

**1-800-600-2073, ext. Q1786**  
For information on all our products: [www.bose.com/q1786](http://www.bose.com/q1786)

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City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_  
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**BOSE**  
Better sound through research.

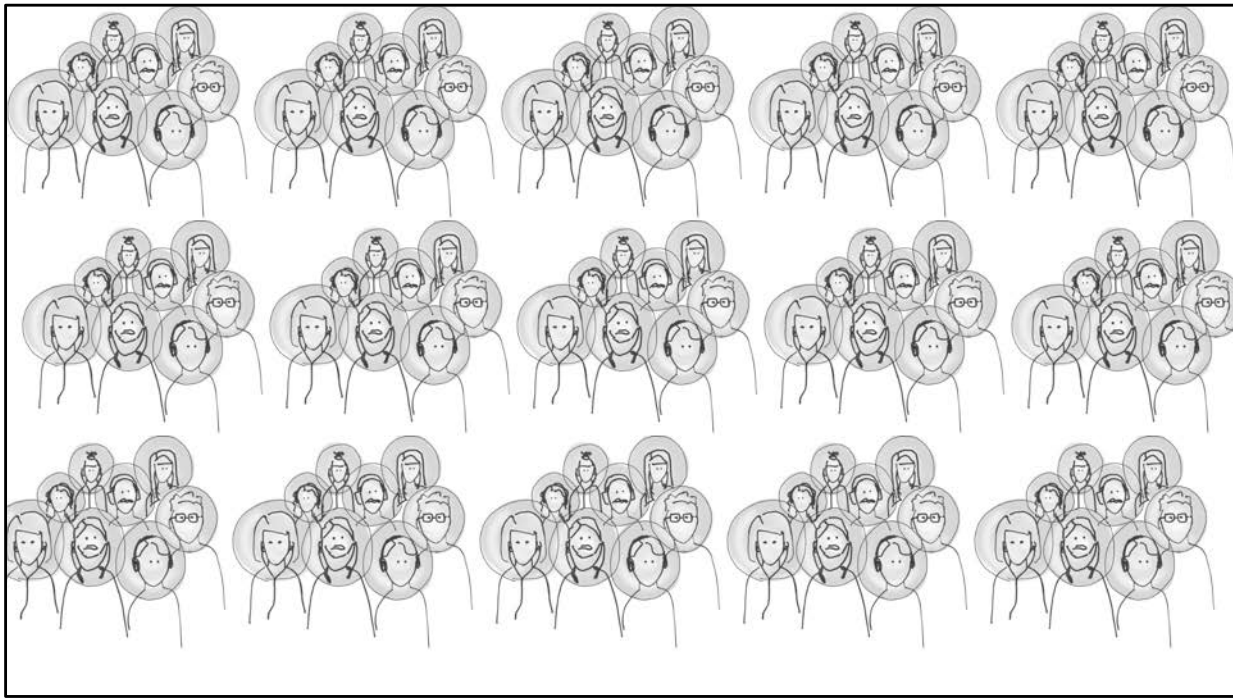
\*Offer requires a 2-year agreement. Payment required. \*\*Offer requires a 2-year agreement. Payment required. ©2003 Bose Corporation. All rights reserved. Bose, the Bose logo, and QuietComfort are trademarks of Bose Corporation. All other trademarks are the property of their respective owners.

While our consumer headphones started in the crowded seat rows of airliners, offering you sanctuary from both the noise of the jet but also that guy in the middle seat that you really don't want to talk to, they moved from there into noisy office spaces and, with time, onto the street. Others rode our coattails, most notably Beats.





Beats deserves the credit for turning headphones into what else they've become for many. Through celebrity endorsement, they evolved headphones from being not just a shield from unwanted noise of city life, but also a fashion accessory – like glasses or sunglasses – or a statement or of group affinity.



Now, all around you in public spaces, you see people in their headphone bubbles.

Is it good for so many people to be walking around in sonically isolated bubbles? Is it safe, given the impact on situational awareness? I'd argue that these bubbles are a natural or even healthy response to crowded city living that is very much the norm for much of the planet. It's a way to make space for yourself mentally and emotionally when you don't have it physically. However, the situational awareness issue concerns me.

Over the last few months I've been monitoring some user research Bose has been sponsoring in Manhattan, looking at the current state of attitudes about headphones. A bike messenger named John told us that his headphones were more important to him than his bike. A barista named Alexis told us how much she loves her Beats and her hip hop. The researchers asked her about needing to hear the sounds around her to be safe. She described an experience where, as she was about to step off the curb into the street, she noticed someone gesturing "stay back!" She paused just before an ambulance that she'd been completely unaware of raced by in front of her. Has she changed her behavior, taking off her headphones or turning down her music while out walking? Not really, though she claims she looks around more.

Cities are crazy, noisy, chaotic places. Music and sound is a buffer, an emotional recharge – again, a way to make your own space in the city. That's what headphones have become.



Over the last decade, the devices these headphones are connected to have changed. The iPod has been replaced by the iPhone and other smartphones.

1000 songs in your pocket? How about the 30M on Spotify?





But now, not only are people's ears not situationally aware, but their eyes and minds aren't either. Worse yet, the distraction is there even when you don't choose to waste some time.



Reach anyone, anywhere, by phone call or Facetime or SMS or WhatsApp or Snapchat or countless tools.

Have a question? Consult Google.

Have some spare time? You can disappear down the rabbit hole of social media or whatever is today's equivalent of Candy Crush.



## Smartphones and Cognition: A Review of Research Exploring the Links between Mobile Technology Habits and Cognitive Functioning

Henry H. Wilmer, Lauren E. Sherman and Jason M. Chein\*

Department of Psychology, Temple University, Philadelphia, PA, USA

A growing body of work is examining how these ever-present devices and the apps on them affects us. Articles have been popping up in the press, particularly over the last couple of years. I'm not talking about the whole question of possible manipulation of politics in the western world by means of social media. I'm talking about how these tools always at hand, if not in our hands, effect us cognitively. A friend at work found this survey article from 2017 that critically assessed the research to date.

#### Attention effects

"Once attention has been shifted to the smartphone for one purpose ... users often then engage in a chain of subsequent task-unrelated acts on the smartphone, thereby extending the period of disruption. Studies exploring these 'within-phone' interruptions have found that task completion in one app can be delayed by up to 400% by an unintended interruption from another app."

*Wilmer et. al.,  
citing work by  
Leiva et. al.*



They cited work that showed that, when one's attention shifts to a phone to do something, that people often engage in unrelated tasks because of within-phone interruptions or notifications. The cited research said that completion of the originally intended task can be delayed up to 400%.

Have you ever done that? You want to check your email so you pull out your phone or do a search for something. Then a notification red-bubble on an icon catches your eye, or you see the icon for some app and you tap it. You scroll, you tap a like, your mind flits from thought to thought. Minutes pass before you realize that you still haven't checked your email.

### Self-regulation

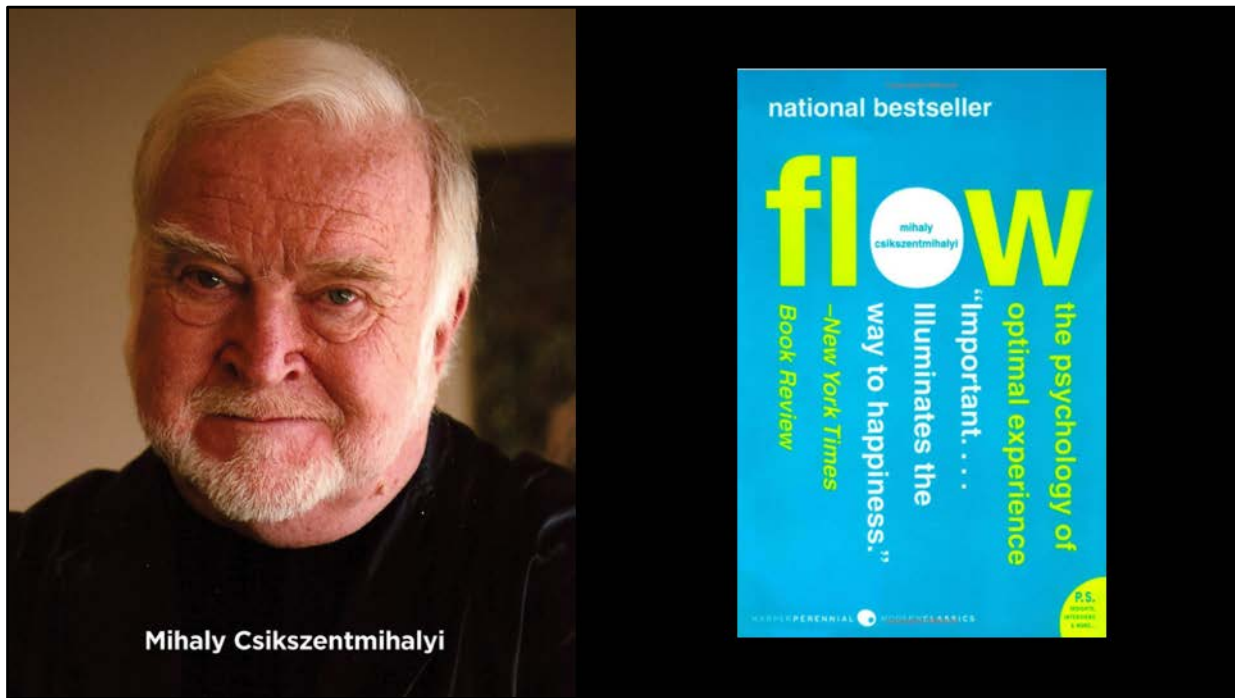
"The results showed that the individuals who scored highest on the smartphone addiction scale scored significantly lower on the self-regulated learning and learning flow scales."

*Wilmer et. al.  
citing work by  
Lee et. al.*



Other work, by Lee *et al*, surveyed a large sample of university students regarding their smartphone and learning habits. Lee found a correlation between high addiction to smartphone use and low self-regulation of learning habits. Now, correlation is not causation. Perhaps people who have less self-regulation skills, a less developed executive function, may just become more easily addicted. But, perhaps, there's more to it than that.

Part of what Lee and team were assessing in their subjects was the ability to achieve "flow" in learning. I recognized that term and another author cited.



I recognized him not only because of the name that I wish I knew how to pronounce. Does anyone here speak Hungarian? I was already aware of his research into the idea of 'flow' which he did while at the University of Chicago. A former president of the American Psychological Association called Mihaly the "world's leading researcher on positive psychology." I think that's a good topic to learn about! And, I'll call him by his first name lest I butcher his last.

My wife had given me a copy of the first edition of this book in the 90s. She saw how I looked for chances to immerse myself in problems and that – when things clicked – I was at my happiest. For me it's a comfortable chair, a view of trees, a laptop and Matlab plus an interesting question. Or sometimes cooking. Or Aikido. Where do you most find your flow?





Mihaly defines flow as a time when a challenging task and our skill come together in a way that totally absorbs us. It can be intellectual or athletic, musical or in any of the arts. Almost anything creative.



"People are happiest when they are in a state of flow, a state of concentration or complete absorption with the activity at hand and the situation. It's a feeling of great absorption, engagement, fulfillment and skill."

"We feel in control of our actions, masters of our own fate. We feel a sense of exhilaration, and a deep sense of enjoyment."

*Mihaly Csikszentmihalyi,  
Flow*

In his first book he says that

"People are happiest when they are in a state of flow, a state of concentration or complete absorption with the activity at hand and the situation. It's a feeling of great absorption, engagement, fulfillment and skill."

"We feel in control of our actions, masters of our own fate. We feel a sense of exhilaration, and a deep sense of enjoyment."

Let's turn back to Wilmer et al's review of smartphones and cognition.



“...those who reported engaging in more media multitasking were also less able to filter environmental distractions.... Additionally, frequent media multitaskers exhibited higher switch-costs in a task-switching paradigm.”

*Ophir et. al.*



Work by Ophir and others cited in the paper described using a questionnaire to assess subjects' use of media, from which they determined a media multi-tasking index. They then had subjects do computer-based behavioral tasks to assess attentional functioning. The data showed that those who reported engaging in more media multitasking were also less able to filter environmental distractions,” defined as task stimuli that were inessential to the primary task. They also found that “frequent media multitaskers exhibited higher switch-costs in a task-switching paradigm.”

While we tell ourselves we can do it, I think we all know deep inside that multi-tasking is largely a fallacy. In narrow circumstances perhaps, juggling related tasks toward a single purpose, such as in gaming. But in day to day life, juggling diverse unrelated tasks? Not so much. The cognitive switching costs are too high.

We don't need tools to help us multi-task. We need help using our tools to get better at single-tasking.



Two people who've been getting attention related to mobile tech and its effects on us are Tristan Harris and James Williams. Williams worked for ten years in search advertising at Google, and Harris was for three years a design ethicist there, till he quit and founded the Center for Humane Technology.

I've not read Williams's book, but Harris's piece (shown on the left) on medium.com is an interesting listing of all the ways app design is used to maximize our screen time, capturing our eyeballs and thumbs. BF Skinner would recognize the use of random reinforcement operant conditioning. We're trained with little rewarding shots of dopamine when we get a notification and check our feed, only to see a like or two.



“an entire army of jets and tanks aimed at capturing and keeping our attention. And the army is winning. We spend the day transfixed by our screens, thumb twitching in the subways and elevators, glancing at traffic lights.”

“The liberation of human attention may be the defining moral and political struggle of our time.”

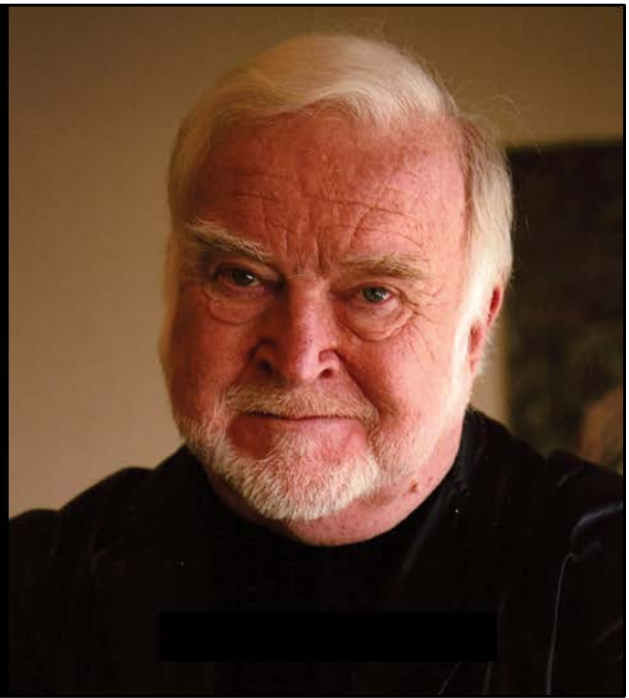
*James Williams*

In a column in the NY Times last August both Williams and Harris were interviewed. They didn't mince words, Williams – the former search ad guy – in particular.

He compared the current design of our technology to “an entire army of jets and tanks” aimed at capturing and keeping our attention. We spend the day transfixed by our screens, thumb twitching in the subways and elevators, glancing at traffic lights.

In his book he wrote: “The liberation of human attention may be the defining moral and political struggle of our time.”

"To be distracted against one's will is the surest sign that one is not in control. Prolonged experiences of this kind can weaken the self to the point that it is no longer able to invest attention and pursue its goals."



Let's turn back once more to the words of Mihaly, the expert on the psychology of optimal experience. In his book *Flow* he wrote:

"To be distracted against one's will is the surest sign that one is not in control. Prolonged experiences of this kind can weaken the self to the point that it is no longer able to invest attention and pursue its goals."

To me, that ties back to some of what I quoted from Wilmer's review article earlier. It fits with heavy use of smartphones *causing* a weakening of our ability to self-regulate and focus on what matters.

And do the bursts of dopamine we get in reward for our use of these apps make us happy?

*The Atlantic*



"The results could not be clearer: Teens who spend more time than average on screen activities are more likely to be unhappy, and those who spend more time than average on non-screen activities are more likely to be happy. There's not a single exception. All screen activities are linked to less happiness, and all non-screen activities are linked to more happiness."

*Jean Twenge,  
San Diego State Univ.*

Jean Twenge of San Diego State University says "no". In her 2017 article in The Atlantic, describing her research into what she refers to as "iGen" she says:

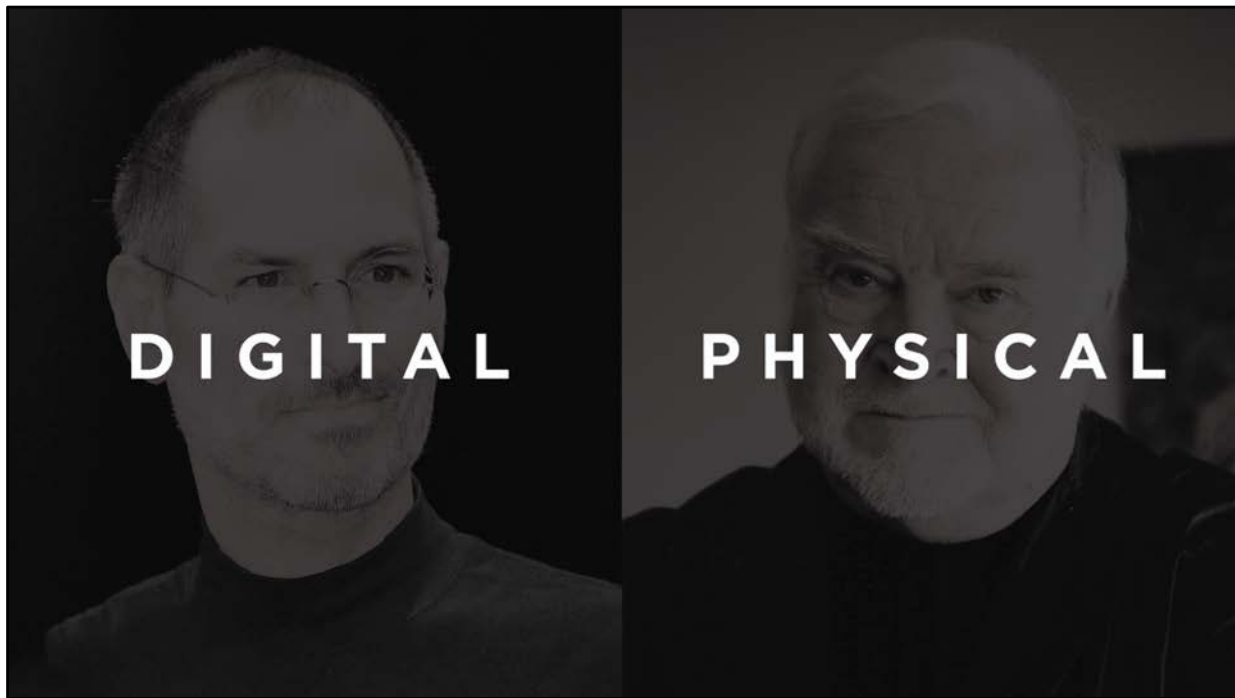
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Hmm. What to do? How are you feeling about the future right now?

Now, I'm not a Luddite, starting a movement to smash all smartphones and headphones for what they do to us. They can do much for us that's of value. I *do* recommend, like many experts on this stuff, turning off all notifications but those that you really need.

Speaking as an engineer who helps shape technology products and experiences, I think we can do better. I want to wrap this up by describing some steps in what *I think* is the right, or a better, direction. I'm blessed with a job where, for about the last 15 years, I've had lots of freedom to daydream about the future and what we can do to augment our ears and our voice – hearing and speech – super-powering them to help us better master and enjoy life in the physical world. To help us take control of whatever sound the world deals us.



More recently, I've been thinking about how the digital and the physical world come together. How to mix them, master them and enjoy the wider range of possibilities digital plus physical affords us. For me, a lot of this crystallized in San Diego, just before NHCA three years ago. I'd been in San Francisco for work the week before and, rather than flying home to Boston, I came down to San Diego and rented an Airbnb on Mission Beach. I got into a real state of flow, thinking and writing about things I wanted to see happen at Bose, and in the larger technology world. A rough rev-0 of this story came together.

I believe that headphones of the future will help. They'll give us control over the sound of the physical world around us that our ears don't naturally have, and help ears that have suffered from noise or the just the consequences of time. And, they can help us master the digital world at the same time. I hope we all find our way to a bit more Flow in the process.

I want to talk about a few examples, early proof points. Let me actually start with getting better at mastering the digital. Before I do, let me just declare up front that I'll be talking about some other company's products, but also talking mainly about those of my employer. It's hard for me to talk about the future that I see coming and have been trying to influence without talking about our products. Those products are the language of my life's work.

I'll start with this...



Leave your phone in your pocket or purse.



As much as you can, leave your phone in your pocket or purse. Resort to the screen only when you need to. As I said before, turn off notifications as much as you can. You don't need a screen of icons, each with a red badge. Each of those badges, each ping pulls you away from what you've previously chosen to do. The best way to not get trapped in your screen is to not look at it.

Instead, use your voice. Just ask for the information you want. Say "Hey Siri" or "OK Google" or "Alexa". (Sorry if I just woke up a few phones scattered around the room!) VPAs (aka "virtual personal assistants") have become a thing in the home, disrupting the speaker market. It's moving outside the home – just look at Apple's success with their AirPods. Jeremie lampooned them last year with a picture of a toothbrush in his ear. But, they're selling like hotcakes. AirPods are sleek and small and amazingly convenient. They don't do anything about the noise around you. And sound quality – no comment. Clearly it's good enough for lots of people.

How can headphones and VPAs help address the issues with smartphones that I mentioned before. Quoting one last time from Wilmer's review of the cognitive effects of smartphone use, he writes: "some evidence suggests that the more "rich" (for example, including a visual image rather than just text) the information encountered during an interruption, the more detrimental the distraction is likely to be with respect to primary task completion." So, vibrant colorful screens, red badges you've been conditioned to tap, dancing graphics, etc. grab your mind and pull you down the rabbit hole. If a voice interface is well-designed, not pushing notifications to you, that shouldn't happen.



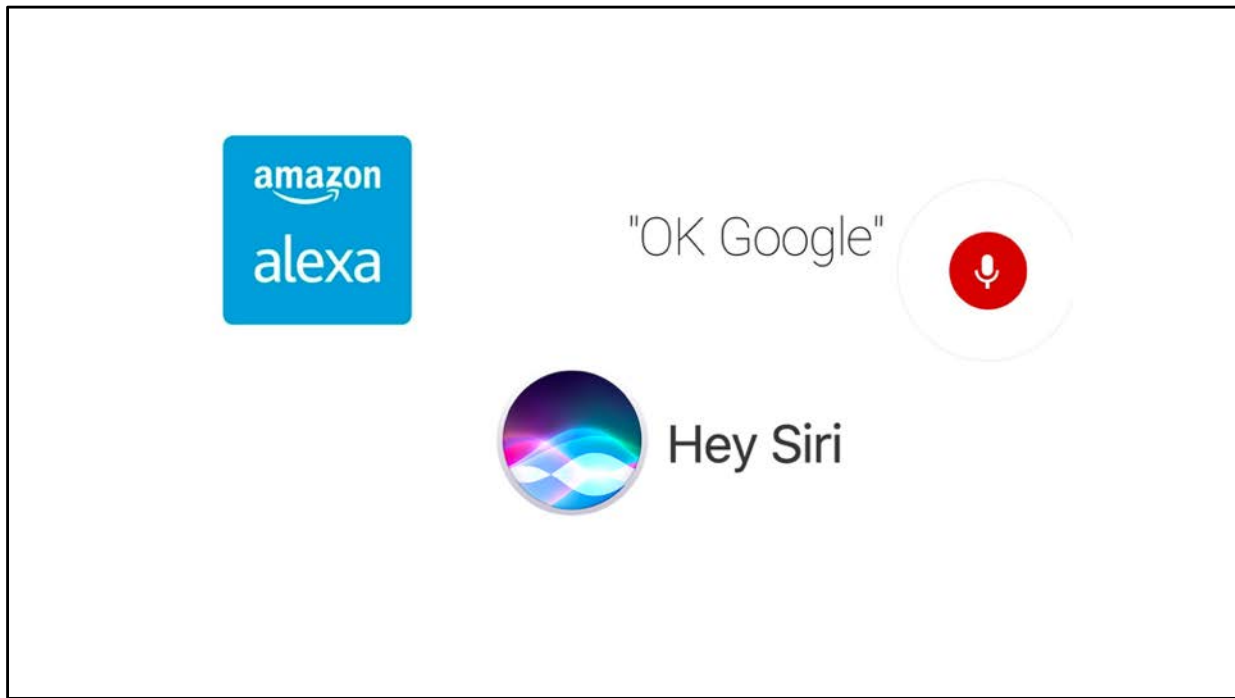


For another option that leaves your ears feeling – and in this case looking – open to all the sound the world offers, while allowing music to float ethereally yet privately around you there’s what Bose calls Frames. Glasses – sunglasses for now – that are also Bluetooth headphones. Use them to live life heads up, hands free.

If you want a demo sometime during NHCA, grab me. I have a set. They’re new, I unboxed them last week. And they’re up for bid in the Silent Auction. I’ll also tell you a little about our new audio augmented reality platform that we are launching around Frames.

The idea behind wearing AirPods or our Frames or any other headphone with VPA integration is, to me, this. Thoughts floating around in our minds can be visual or they can be verbal. But, I believe for most people, when that thought crystallizes into something specific and actionable, it more likely than not is verbal. If it’s something that you can ask a system to do for you, that you can get from the internet, that means the shortest path from that thought to getting what you want is your voice. Not unlocking your phone, swiping and tapping. And not getting distracted by a red notification badge. Ask, and answer. That’s the dream.

We’re a ways from that dream working seamlessly, but it’s getting closer.

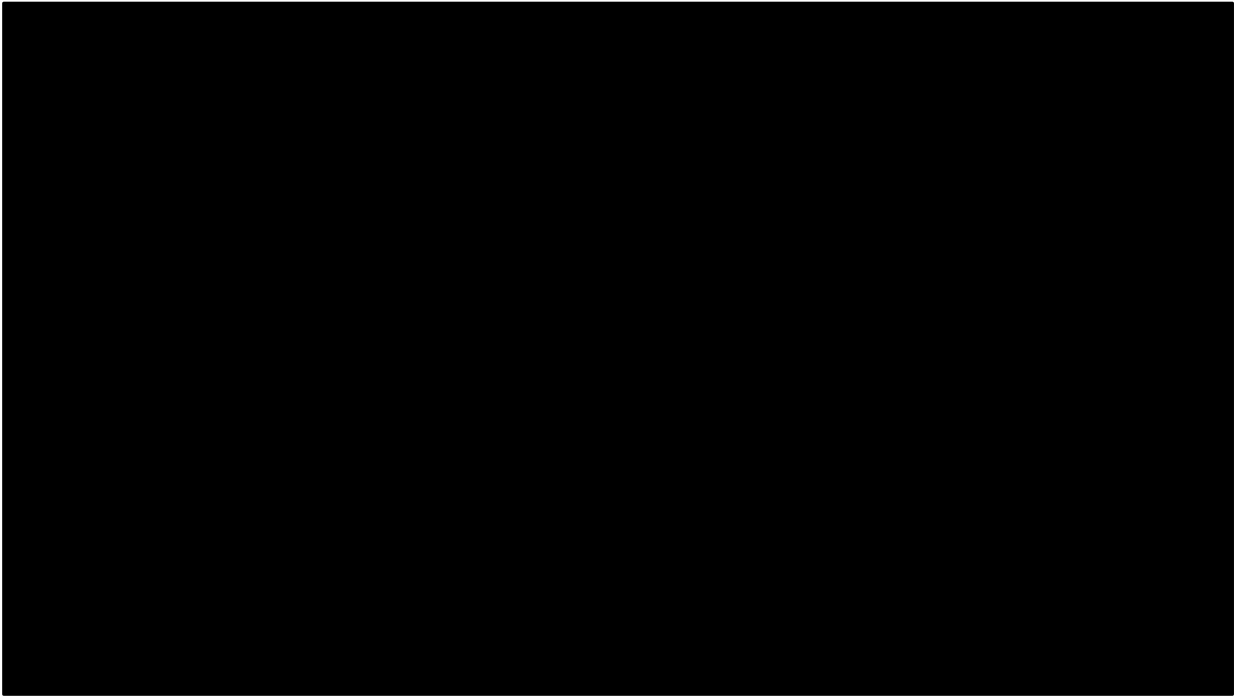


Back to VPAs. How many of you have experience with one – have an Amazon Echo or a Google Home or an Apple Homepod at home? How many of you wouldn't let one in your house, just like you tape over the camera on your laptop?

OK, just like most apps in your app store of choice, most of what you can do with these things are silly. I've heard that most people just use Alexa to check the weather or as a hands-free kitchen timer. The ability to understand questions beyond simple ones is limited and the failures to understand what you say is at times laughable. But, the natural language understanding, the grasping of context, will get better and better. With time, they'll be able to do more, becoming more useful.

Do I trust these companies, having these things listening in my home? Pretty much. I know they're not constantly monitoring; they need a wake-word to start sending data to a distant server. That said, I do like the idea of using a device not made by the VPA-operator because it means they have less direct control over the interface into my home. I'm starting to replace the Echo Dots in my house with Bose smart speakers, in part for this reason. Besides, we sound much better playing music. And if you want to use a VPA on-the-go outside the home, our current top-of-the-line noise canceling headphone can be used with all three of the major players shown. Your choice.

I do use, at times, all three VPAs, but mainly Alexa and Siri. I have five Alexa nodes scattered around my house. Most of the time that's how we control the lights. But the main time I appreciate them is at night in the dark.



I wake up a lot at night, and wake up slowly in the morning. I'm not one to bound out of bed, particularly at 0-dark-30. When my alarm goes off, I love being able to just lie there, telling Alexa to "stop alarm" and then to turn on the lights. I can lie there for a moment or two before opening my eyes.

But it's more important in the middle of the night. Years ago I read a book by David Allen called Getting Things Done. I don't follow his advice with care, just bits of it – I'm not disciplined enough. The key thing that stuck with me from his book is the observation that we all have digressive minds. We're trying to do one thing but thoughts about something else pop in. He advises having a trusted system to put those thoughts in quickly and efficiently, so you can get back to what you were doing. I bet David Allen has ALL the notifications turned off on his phone!

This idea helps me in the middle of the night. As I said, I wake up a lot. Too often, having slept just a few hours with some problem turning over deep in my mind, I'll wake up and start thinking. If an idea surfaces or just a thought of something I need to do, I think "got to remember this." And as a result, too often, I'm suddenly wide awake.

This all got a lot better when the company that puts out a to-do list program I use called Things integrated Siri into their system. Now I can wake up with a thought and, barely awake, just say "Hey Siri" and leave a reminder. It appears in my system when I need it. How about a demonstration? "Hey Siri. In Things remind me Saturday to buy a jigsaw puzzle for Susi at the airport." Occasionally what pops up in my Things list days later is a bit odd, needing some interpretation. But, most of the time it works well. Well enough that I can roll over and go back to sleep easily.

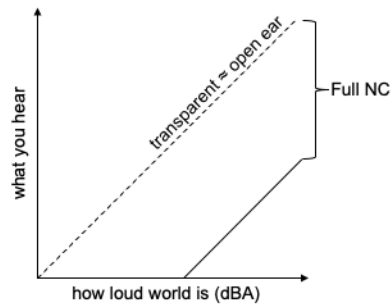
"We cannot think, truly, originally  
—and be ourselves—without quiet."

**"Silence is the think tank of the soul."**

*Gordon Hempton*

Next, let's turn from using our voice for mastering the digital with less distraction to empowering our ears. Of course, we have noise cancellation combined with passive attenuation to turn the world down. Particularly when combined with music it creates the the isolating bubble that I described before, people carving out space for themselves in busy urban centers.

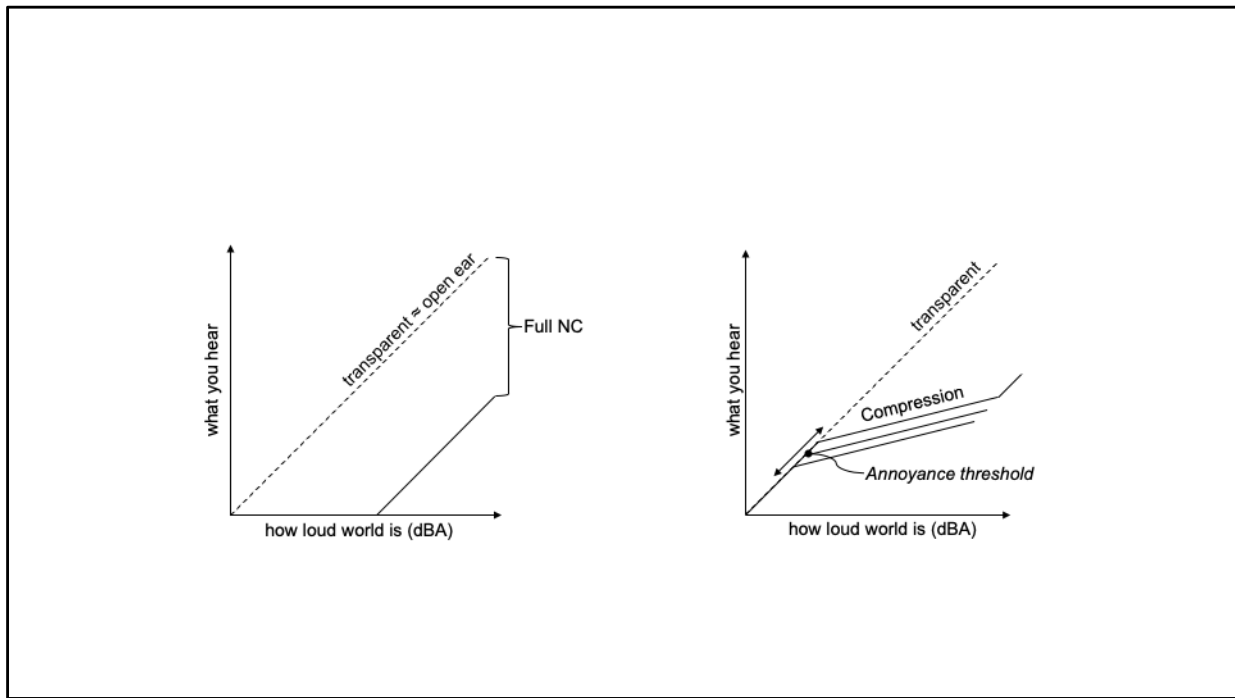
When I'm trying to totally focus, sitting in my office with people talking in the next office over or at a Starbucks, I don't turn to music. Instead I use a recorded loop of a babbling brook that I've tweaked for masking. The attenuation means the masking can often be set to a very quiet level. All I hear is the stream. It's just me and my thoughts. A colleague named this experience "cognitive silence." And, after years of doing this, the sound of that stream has become a trigger to get me to roll up my mental sleeves and get into the Flow.



But, I'd never do this walking a city street. Earlier I said that the degree to which people isolate themselves in these bubbles, impairing their situational awareness, concerns me. But I also want a buffer from the noise of the city. When I'm out and about in a place like New York, I want to hear the energy of the city, but at my choice sound level.

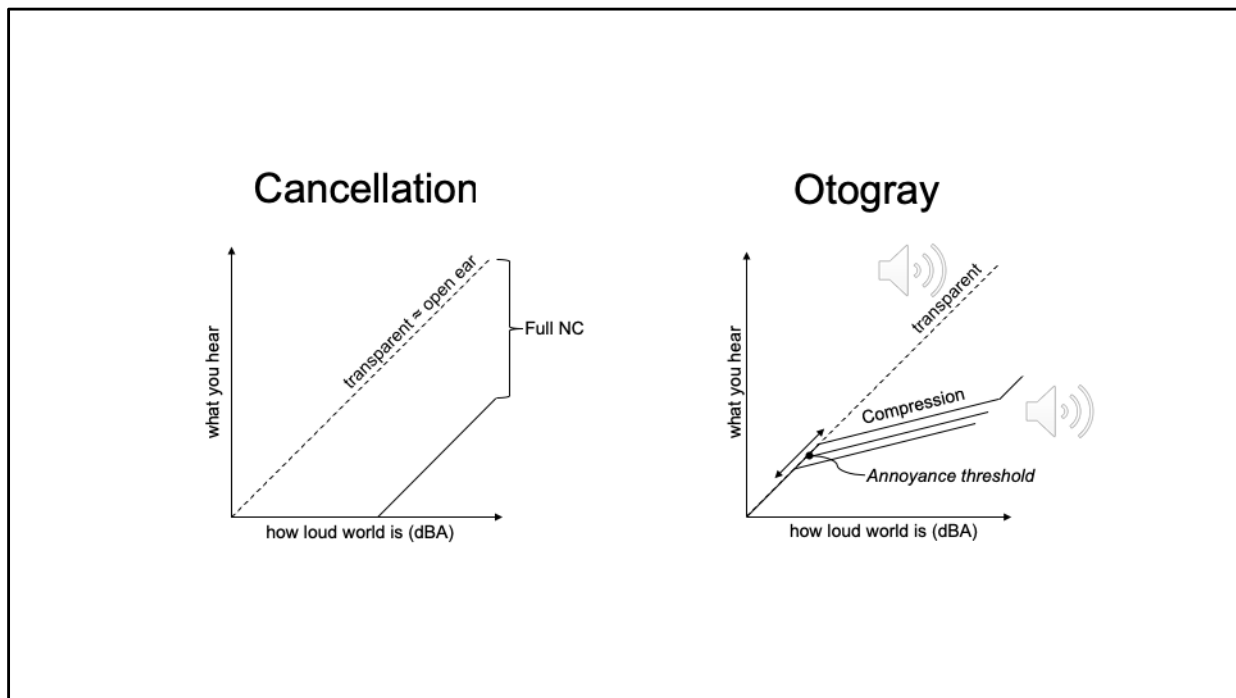
We're experimenting with a way to turn noise cancellation on it's head, using it to enjoy hearing more, rather than – to make up a verb – just for not-hearing. Our headphones have microphones that look both into your ear canal and outward; we use those together to cancel as much as we can. But, we can re-jigger the processing to the outward facing mic, passing through sound and carefully equalizing it to make the headphones transparent. In essence, we restore 0 dB insertion gain. And we can do anything in between.

Let's look at it as an input / output diagram. This diagram shows things as they operate today. The X-axis is how loud the world is, the Y what you hear. The dashed line is when the outer mic processing, what we call feedforward, is set to achieve transparency and the solid line is full cancellation.



What we're experimenting with is a system that is transparent when it's quiet, but when you cross over your personal threshold of annoyance, that you don't like it louder than, cancellation is dialed in on slow time-average basis. The system compresses, maintaining flat attenuation but adjusting the amount automatically. You get to set your annoyance threshold; in the prototype I use all the time I have it set to about 67 dBA. You hear the world, and all the modulations, naturally. The system just rides the volume.

Let me give you an analogy to glasses. When what are now called Transitions lenses first came on the market, they were called Photogray. Not exactly a marketing-friendly term.



When this idea was first proposed at Bose, my colleague Bill Rabinowitz called it “otogray.”

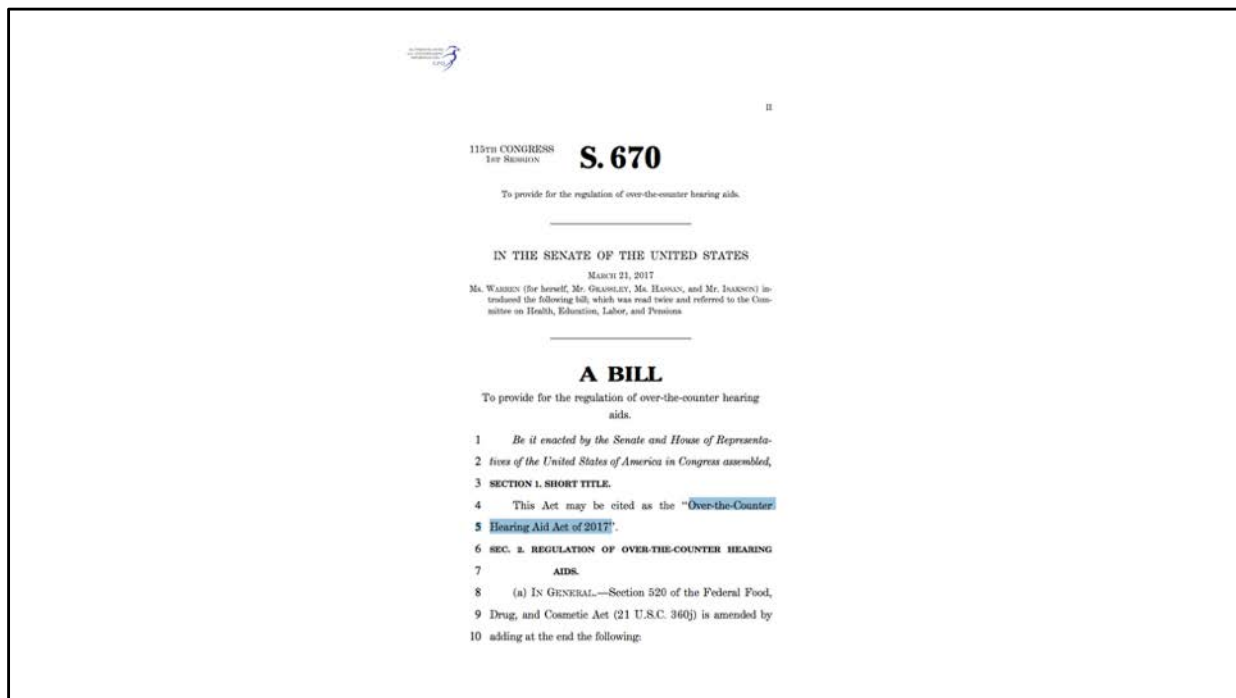
How about a demonstration, in simulation at least? Here’s a short recording of a scene at a sidewalk café. You’ll hear birds chirping, a server speaking to you – then a bus drives by.

Not so pleasant, right?

Now listen with otogray running. You hear the birds, the server – but the roar of the bus’s engine as it accelerates is quieted.

In my experience, this makes the sound of city sidewalks and many other situations more pleasant. You hear what you want, while staying comfortable. And when it gets loud, you can still hear what’s coming from your VPA or your music, without having to make it super loud.



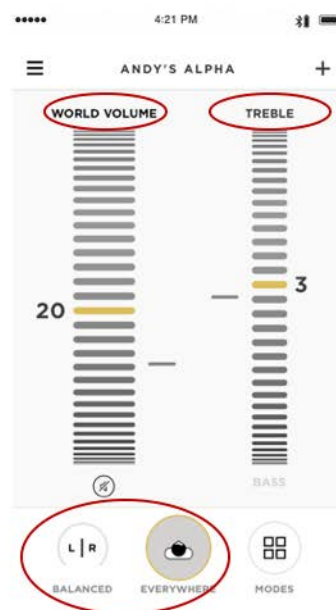
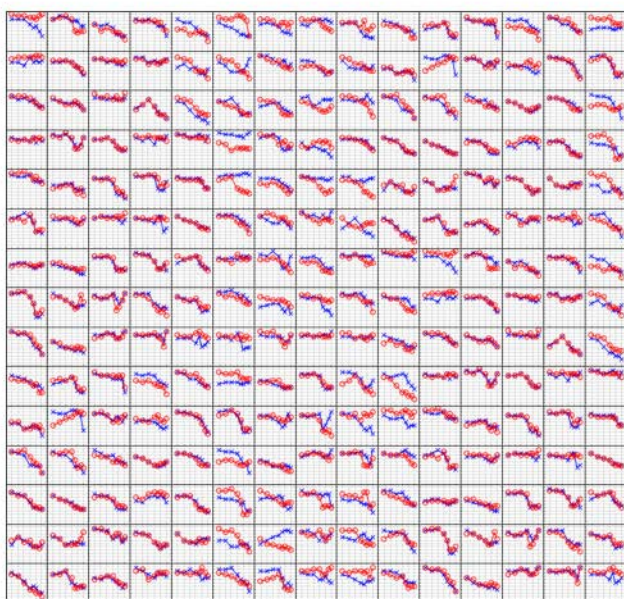


Finally, let me turn to empowering the ears of people with hearing loss from noise or age-related – and empowering the people who own those ears. There’s been a movement for some time to open-up access to hearing assistance, and of course, there’s been resistance to it. You all no doubt know much about this. Mead Killion and Gail Gundmundsen deserve much credit for pushing this, for years. Things started to come together during the Obama administration and, in 2017, Congress passed this bill directing the FDA to define a regulatory framework for over-the-counter hearing aids by late 2020.

Bose played a role in shaping and encouraging this, most notably my now retired colleague Dianne Van Tassel. I just played a small part in getting Bose involved and shaping early aspects of the product.

Of course, with an OTC aid, a key question that arises is how does a user ‘fit’ it to their hearing? I want to describe work that Andy Sabin, another Bose colleague, and Dianne led to prove the efficacy of the approach we’ve taken to this question. This work, funded by a grant from NIDCD (R44DC013093) that Andy and Dianne brought with them when they joined Bose, was the basis for a *denovo* submission we made to the FDA. That was approved last Fall and now, in advance of rulemaking related to the OTC Act, Bose has permission to sell self-tuned devices and call them hearing aids.

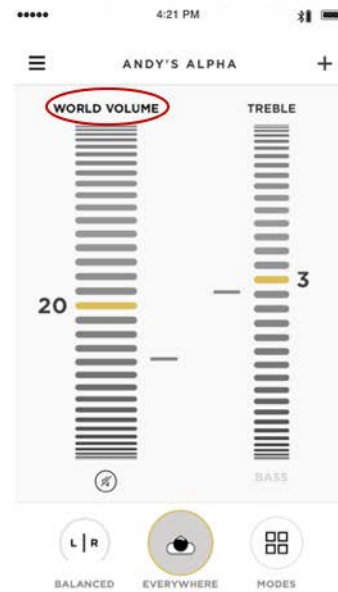
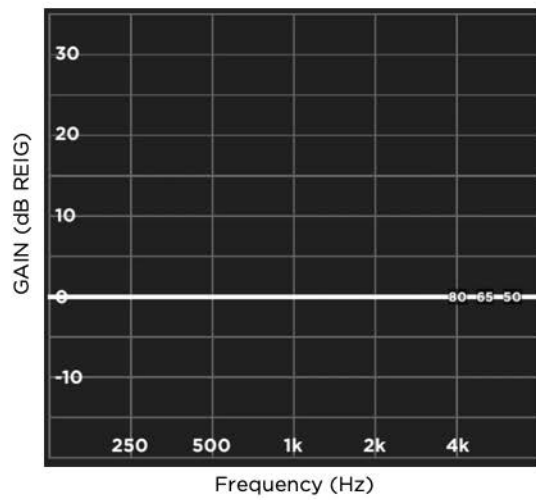
That said, we’re not doing it yet. The Hearphones that we’re selling today are a PSAP. They weren’t developed under various FDA rules.



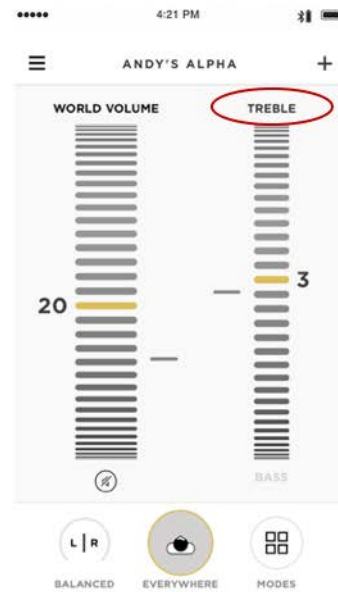
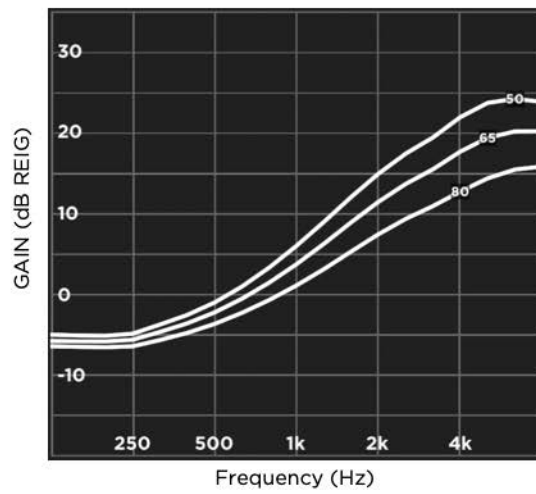
So, how has Bose chosen to let people self-tune Wide Dynamic Range Compression? Let me go through a few slides that I borrowed from Andy. He presented this in more depth at IHCON last Summer.

It started with a statistical analysis of a large set of the NHANES database. Doing what's called a principle components analysis, Andy found that he could capture in excess of 90% of the variance in WDRC parameters fit using a standard prescription using just two parameters. The graphic at left illustrates it, but many more – thousands – of audiograms representing mild to moderate hearing loss were factored in.

This led to what we call the World Volume and Bass / Treble controls in the app that goes with our Hearphones. A third control at the bottom of the interface lets the user manage the 2-by-2 mic directionality, choosing among three settings; I won't talk about that today. And, a fourth control can be used to bias the WDRC settings asymmetrically between the left and right ears.



As a user manipulates World Volume, under the hood many WDRC parameters are changed in a coordinated way, increasing gain according to the primary variation determined from the analysis of thousands of prescriptions. The video at left illustrates it.



As for the secondary parameter – Treble / Bass – it extends the range of prescriptions that can be fit. It essentially affects the tilt of the gain, as shown by this video.

How do outcomes – REIG, user preference & benefit compare when WDRC parameters are chosen by the user vs. clinically?

	CLINICAL GROUP	SELF-FIT GROUP
SAMPLE SIZE	37	38
4FA HEARING LOSS Avg(sd)	29(9) dB HL	33(12) dB HL
AGE Avg(sd)	62(13) Years	66(12) Years
HEARING AID EXPERIENCE	33 New Users	28 New Users

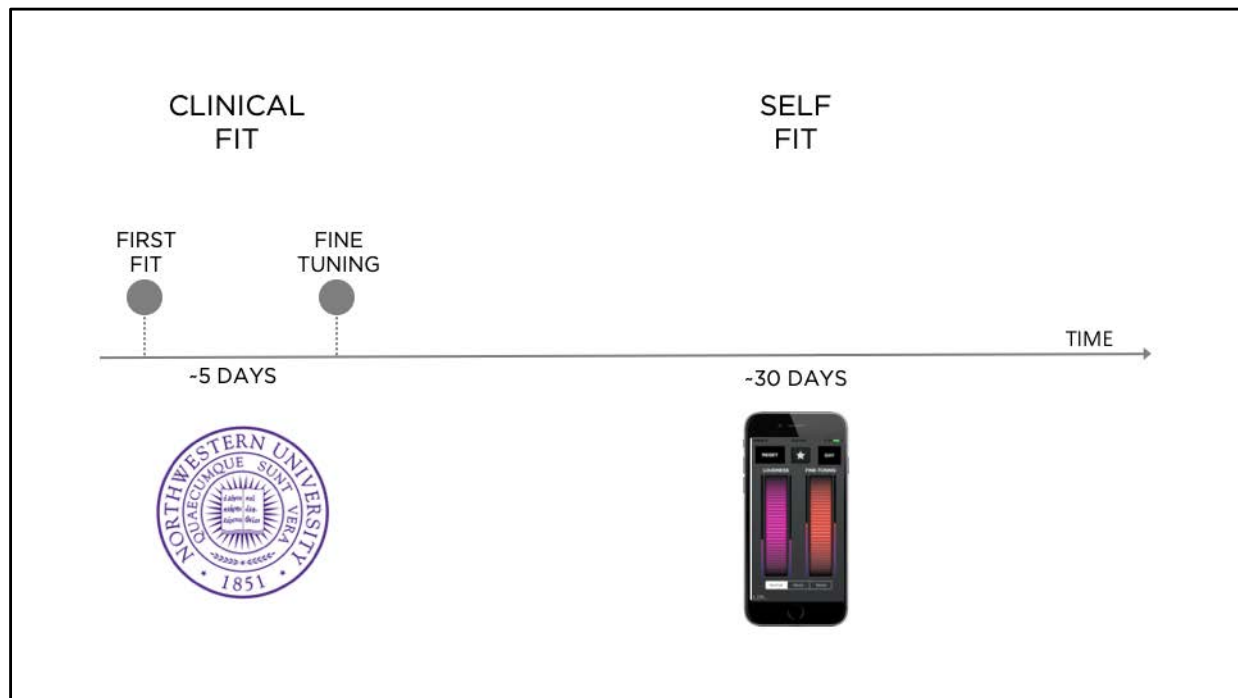


How well does it work? How much gain do users choose? Do they over-amplify? What's the comparative benefit and preference?

Andy and Dianne tackled those questions in the study underpinning our *denovo* submission. The hardware used was similar to and based on our Hearphones, with a special app used to enable the experiment.

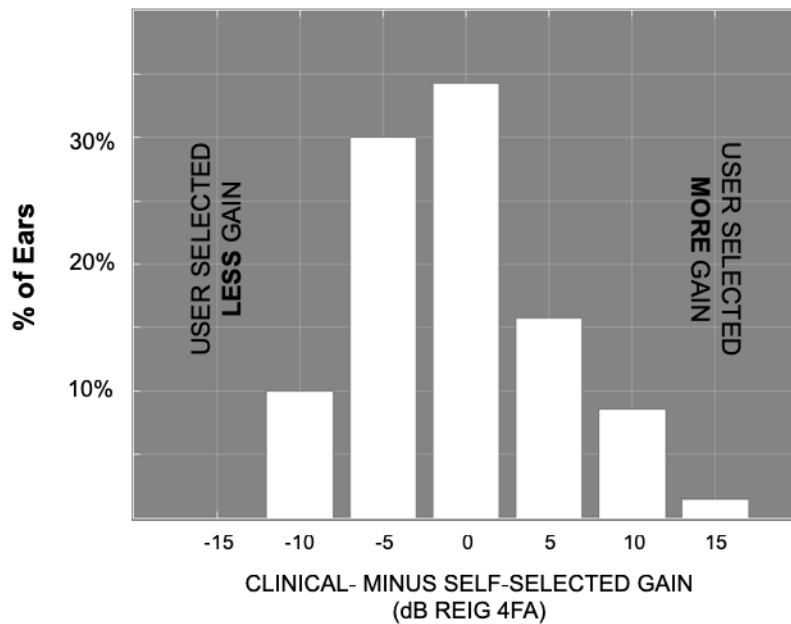
A group of 37 subjects was recruited and put through an audiometric evaluation and, if they qualified, the WDRC was tuned using the experimental app which gave access to all WDRC parameters to the audiologist doing the fitting. The table above shows the profile of the subject pool.

Subjects lived with the device for about five days then they returned for a fine-tuning session. This resulted in what was called the "Clinical Fit".



After the Clinical Fit was obtained, subjects were given a prototype related to our current Bose Hear app, set to a neutral setting – unrelated to their clinical fit. They used this in the field in their everyday lives for about 30 days, adjusting the wheels so they could hear the world the way they wanted to – what sounded ‘right’ to them. A button in the app when the user was done adjusting for a situation. On average, over the 30 days, users logged 88 adjustments in the field. Each can be considered a User Fitting – the following graphs report the within-user mean fittings.

So, the critical thing to understand is that, for each user, we had a Clinical Fit and a User Fit.



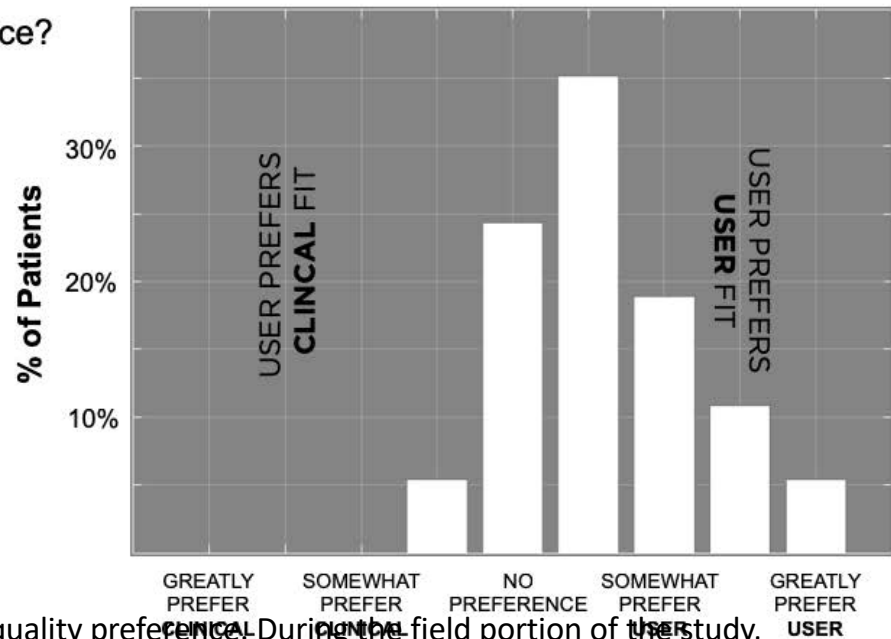
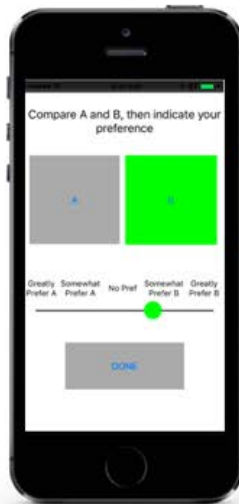
Let's look first at the question of how much gain users chose. This histogram shows the difference in the 4-frequency average gain, Clinical Fit minus Self Fit. Notice two key things.

The mode of the data is 0 dB difference. Looked at another way, the average difference across users was  $-1$  dB.

The next highest bar is at  $-5$  dB. A majority of users chose less gain than the Clinical Fit – so users don't tend to over-amplify when given control.



## Sound Quality Preference?



Next, let's look at sound quality preference. During the field portion of the study, when users pressed the button indicating they were satisfied with their adjustment of the wheel, they were presented with this screen. After a period of silence, they were allowed to listen to and then choose between two settings, A or B. One was their Clinical Fit, the other was their Self Fit and of course it was randomized. After listening, they moved the slider to indicate their preference.

The data at right shows that few users preferred the Clinical Fit; in fact, there is a slight trend toward users preferring their own fitting choice.

For me, this reinforces something I believe. Systems should be designed to give people just the right amount of control, adjusting things that matter to them and – in this case – can hear, while keeping the controls as simple as possible but not simpler (as Einstein said). When this is achieved, people can use them, and people are the best choice as to what's right for them. People know when they can understand the voices around them, and when it gets too loud or uncomfortable. Given the right tools, they'll make the right choices.

I won't claim that what we tested here, and what will underlie our first generation or two of self-fit hearing aids, is perfect. We'll make it better, I'm confident.

Hearing is our most important human sense.

Today's busy / noisy lifestyle and our digital devices  
and apps challenge us, cognitively.

Devices evolved from headphones are starting to empower our  
ears and voices with a new mastery of the physical + digital world.

So, I've come to the end. The things I want you to take away from this talk are as follows.

Hearing is our most important human sense. Cherish it, celebrate it.

The busy and noisy lives we live today, particularly in cities and the apps on our digital devices overload and distract. They challenge us cognitively.

Lastly, I believe that devices evolved from headphones are starting to empower our ears and our voices. They'll allow many of us to take control and achieve a new mastery of the challenges of the physical plus digital world we live in today. In so doing, we'll get more out of life.



Thank you.