Good morning!

I’m going to talk about something that I’m really passionate about. I hope that it taps into your passion for hearing as well. It’s current, touching on large trends in technology and society. Yet, at the same time, it’s grounded in what makes us most human.

Do me a favor. If what I have to say resonates with you or if it doesn’t, let me know. Find me at the conference or send me an email. I want the feedback.

Let me start by simply stating my thesis.
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, there’s mounting evidence that this technology, and design choices built on it, have overwhelmed our cognitive capacity to use it wisely.

But, I believe that we’re entering a new era where we’ll use our ears and voices, augmented by coming technology, to complement our eyes and thumbs. We’ll restore a balance that’s been lost and find a way to better master the complex physical plus digital world we now live in. And because of this we’ll be able to do more, and we’ll enjoy more of what we do.

I’ll start by considering what hearing and speech mean, for us.
Many thousands of years ago, our distant ancestors gathered around fires 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 around shared goals. Community starts with communication. And, while communication can be visual – writing or drawing – it started with spoken language.

Steven Pinker, a cognitive science at MIT at the time he wrote his book *The Language Instinct* said: “In any natural history of the human species, language would stand out as the preeminent trait.”
A 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.”

Thomas Suddendorf, University of Queensland
Philip Lieberman, a cognitive scientist at Brown, put it simply: “We are because we can talk.”

Now, while language started as sounds in air, 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 what might have been unclear at first. It can more easily be skimmed, looking for that idea you remember having seen and highlighted.

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 the brevity of a tweet.
It is this power to bring us together, not just intellectually but also emotionally, 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.
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 the neuroscientist Seth Horowitz. 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.”
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.”
The right music grabs 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.

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 how I spent many hours during my high school and college years.

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. Wearing glasses is even fashionable.
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 involved giving subjects puzzles to solve. They were told that if they couldn’t solve one, they could set it aside and go onto the next. But, 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 dB(A) 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 eradicated. Whether that sound is noise, or not, is in the ear of the ... be-hearer?
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, on city streets and in public places you’ll find headphones in the ears of many, many people.
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 may 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.
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. 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.

Headphones have become buffers and emotional rechargers helping many, many people deal with crowded, chaotic, cacophonous city life.
A decade ago, the iPod was replaced by the iPhone and other smartphones.

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

Have some spare time? You can disappear down the rabbit hole of social media or whatever is today’s equivalent of Candy Crush.
A growing body of work is examining how these ever-present devices – always at hand, if not in our hands – and the apps on them affects us cognitively. This survey article from 2017 critically assessed the research to date.
It cited work showing that, when one’s attention shifts to a phone to do something, people often engage in unrelated tasks because of within-phone interruptions or notifications. Completion of the originally intended task can be delayed up to 400%.

Have you ever done that? You pull out your phone to check your email. A red notification badge on an icon catches your eye. You tap, you scroll, you like or tap thumbs down as your mind flits from thought to thought. Minutes pass before you realize that you still haven’t checked your email.
Other cited work surveyed a large sample of university students regarding their smartphone and learning habits and 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 a less developed executive function may just become more easily addicted to their phones. But, perhaps, there’s more to it than that.

Part of what this cited study assessed in their subjects was the ability to achieve “flow” in learning. I recognized that term and another author cited.
I’ll call him Mihaly; I don’t speak Hungarian and don’t want to butcher his last name. I was already aware of his research into the idea of ‘flow’ which he did at the University of Chicago. A former president of the American Psychological Association called him the “world’s leading researcher on positive psychology.”
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. Or perhaps just time with someone you love.
In his first book Mihaly 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.

“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’s review of smartphones and cognition.
The paper describes work by Ophir that involved a questionnaire to assess subjects’ use of media. They then had subjects do computer-based behavioral tasks to assess attentional function. The data showed that “those who reported engaging in more media multitasking were also less able to filter environmental distractions.” Frequent media multitaskers were also less able to efficiently switch between tasks.

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 media 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.

Harris’s piece 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 likes on something we’d posted.

Both Harris and Williams were interviewed in a column in the Times last summer. Williams – the former ad guy – said: “The liberation of human attention may be the defining moral and political struggle of our time.”
Let’s turn back once more to the words of Mihaly, the expert on the psychology of optimal experience. In his book Flow – first published in 1990 – 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.
Hmm. How are you feeling about the future right now?

Now, I’m not a Luddite, trying to start a movement to smash all this new technology for what they do to us. It 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.

We technologists can do better. I want to wrap this up by describing some steps in what I think is a direction for the better, for us, as human beings. I’m blessed with a job where, for about the last 15 years, I’ve had lots of freedom to daydream and prototype what we can do to augment our ears and our voice – hearing and speech – super-powering them. 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 possibilities that digital plus physical afford 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, so I came down to San Diego and rented an Airbnb on Mission Beach to work for a few days. Away from the distractions of the office, 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 rev-0 of this story came together.

I believe that the headphones of the future can 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 early proof points. Before I do, let me just declare up front that – in trying to place a few dots to define a trend – I’m going to talk mainly about Bose products. It’s the only way I know how to tell this story; those products are the language of my life’s work.

I’ll start with this...
As much as you can, leave your phone in your pocket or purse. Resort to the screen only when you need to. Turn off all but essential notifications. Every red-badge icon that catches your eye traps your mind. 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. Virtual personal assistants – VPAs for short – have become a thing in the home, disrupting the speaker market. It’s just starting to move outside the home – just look at Apple’s success with their Airpods. Airpods are sleek and small and amazingly convenient.

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: “evidence suggests that the more ‘rich’ 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.
For another option that leaves your ears feeling – and in this case looking – open to all the sound the world offers, while allowing music or your VPA 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 and ears open.

The idea behind wearing Airpods or Frames or any other headphone with VPA integration is, to me, this. I believe that, for most people, when a thought crystallizes into something specific and actionable, it more likely than not is verbal. 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? How many of you wouldn’t let one in your home, just like you tape over the camera on your laptop?

Most of what you can do with these things today is 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 are at times laughable. But, the natural language understanding, the grasping of context, will get better and better. Over time they’ll become increasingly useful.

I have five Alexa nodes scattered around my house. 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 don’t bound out of bed at 0-dark-30. When my alarm goes off, I love being able to just lie there, telling Alexa to “stop alarm,” turn on the lights and play the news. 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. 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 into quickly and efficiently, so you can get back to what you were doing.

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, when I wake up an idea surfaces or just a thought of something I need to do. I think “got to remember this” and a memory reinforcement loop kicks in. Suddenly, I’m wide awake.

This all got a lot better when the to-do list program I use called Things integrated Siri. 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 tell it to. Occasionally what pops up in my Things list days later needs some interpretation. But it works well enough that I can roll over and easily go back to sleep.
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. When combined with music it creates the bubbles 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 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.
I’d never do this walking a city street. I want – and would like others – to be situationally aware. But I also want a buffer from the noise of the city. I want to hear the energy of the city, but at my choice of sound level.

We’re experimenting with a way to turn noise cancellation on it’s head, using it to make hearing the world – rather than not-hearing it – better. It starts with passing through the signal from the outward-facing mics on the earbud, carefully equalizing it to restore an accurate 0 dB insertion gain – a sense of transparency.

Let’s look at it as an input / output diagram.
The left 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 is set to achieve transparency and the solid line is maximum cancellation.

What we’re experimenting with is the system diagrammed on the right. It’s transparent when it’s quiet, but when you cross your personal threshold of “this is getting louder than I enjoy”, insertion gain is reduced. The system compresses, maintaining flat attenuation but adjusting the amount automatically.

You may be wondering how this differs from the talk-through on tactical headsets and shooters’ muffs. The key thing is choice of threshold and dynamics. We’re experimenting with this for situational awareness plus comfort in dynamic urban noise – not hearing protection. The threshold is not 85 dB; in the prototype I use all the time I have it set to 67 dB. And, to preserve the natural modulations in sound that carry information, we react slowly.

Let me draw an analogy to glasses. When lenses that darken in sunlight first came on the market, they were called Photogray.
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. Then, quickly, the birds return.

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 – and empowering the people who own those ears. You all no doubt know about the OTC Hearing Aid Act of 2017. This grew out of work over the years, most notably by Mead Killion, to ease access to hearing aid technology. Bose lobbied for this act, notably through the work of my now retired colleague Dianne Van Tasell.

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 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, independent of forthcoming rulemaking related to the OTC Act, Bose has permission to offer self-tuned devices and call them hearing aids.

That said, we’re not doing it yet. The Hearphones that we offer today are a PSAP. They weren’t developed under various FDA requirements.
I want to describe how Bose has chosen to enable people to self-tune Wide Dynamic Range Compression. I’m borrowing from slides Andy used at a talk at IHCON last summer. He tells me that there’s a journal article in the work as well.

It started with a statistical analysis of a large set of the NHANES database. Andy found that he could capture, with just two parameters, more than 90% of the variance in WDRC fittings using a standard prescription. The primary parameter we’ve called World Volume.

As a user manipulates World Volume, under the hood many WDRC parameters are changed in a coordinated way, increasing gain according to the predominant variation in hearing aid prescription across many ears. 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 well does it work? How much gain do users choose? Do they over-amplify? What’s the preference? Andy and Dianne tackled those questions in the study underpinning our denovo submission. The hardware used was based on our Hearphones, with a special app used to enable the experiment.

The study involved two groups whose characteristics are shown on the slide. Both groups used the same hardware, a variant of our Hearphones used with a special app. A control group went through two standard fitting sessions in the clinic at Northwestern then used the device for 30 days before evaluating benefit. The second group was clinically fit, then had a chance to self-fit over 30 days using the two wheels that I just described. During those 30 days, on average each user logged 88 sessions where they’d tuned the wheels so they heard the world the way they wanted to. When they finished adjusting, they hit a “star” button that logged conditions and their settings.
Let’s look first at the question of how much gain users in the intervention group 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.
Finally, 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 adjustments of the wheels, they were presented with the screen shown on the left. After a brief period during which hearing assist functionality was muted, they were allowed to blindly A/B their Clinical and their Self-Tuned Fits. After listening, they moved the slider to indicate their degree of preference.

The data at right shows that only 5% of users preferred the Clinical fit, compared to 75% preferring their Self-Fit.

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 once said). When this is achieved, people can use these systems, and – with the right tools – people know best what’s right for them. Given the right tools, they’ll make the right choices.
So, I’ve come to the end of this talk. The things I want you to take away 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 voices with a new mastery of the physical + digital world. 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.

While this may be the end of my talk, I think we’re at the very beginning of a great new era for ears.
Thank you.