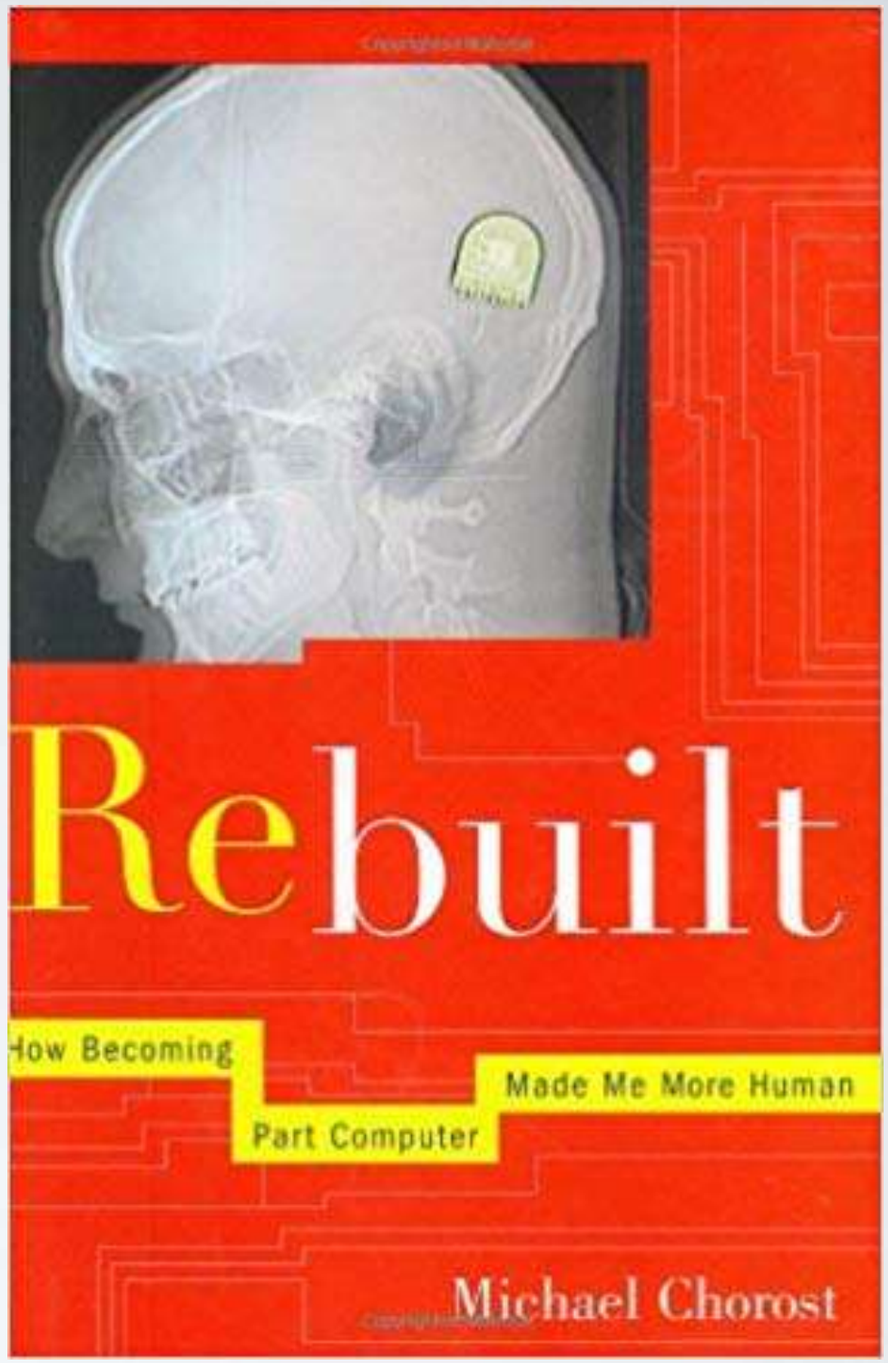
BIONIC EARS: COCHLEAR IMPLANTS AND THE FUTURE OF ASSISTIVE TECHNOLOGY

ENGR110/210, Perspectives in Assistive Technology
Dr. Lindsey D. Felt
Stanford University
ldolich@stanford.edu

“My hearing is no longer limited by the physical circumstances of my body. While my friends’ ears will inevitably decline with age, mine will only get better.”

—Michael Chorost




868


AT&T

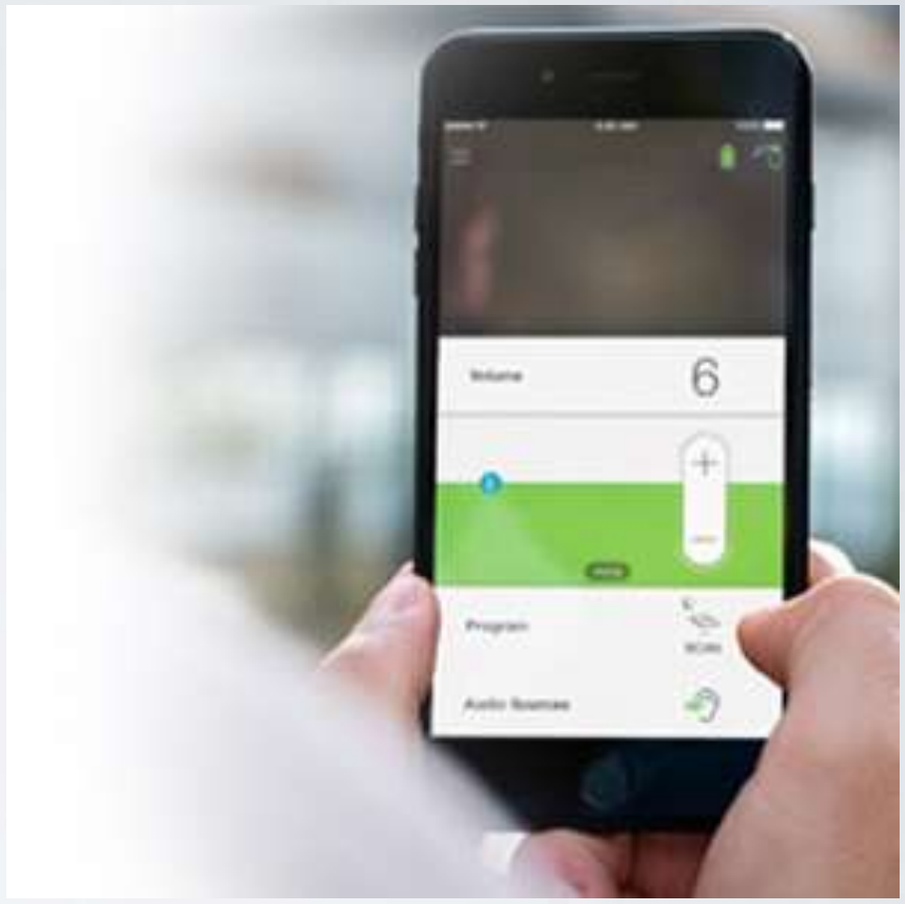
Using Remote Control 2

Adjusting volume

Cochlear™ Wireless Accessories

Hear now. And always.

Cochlear®

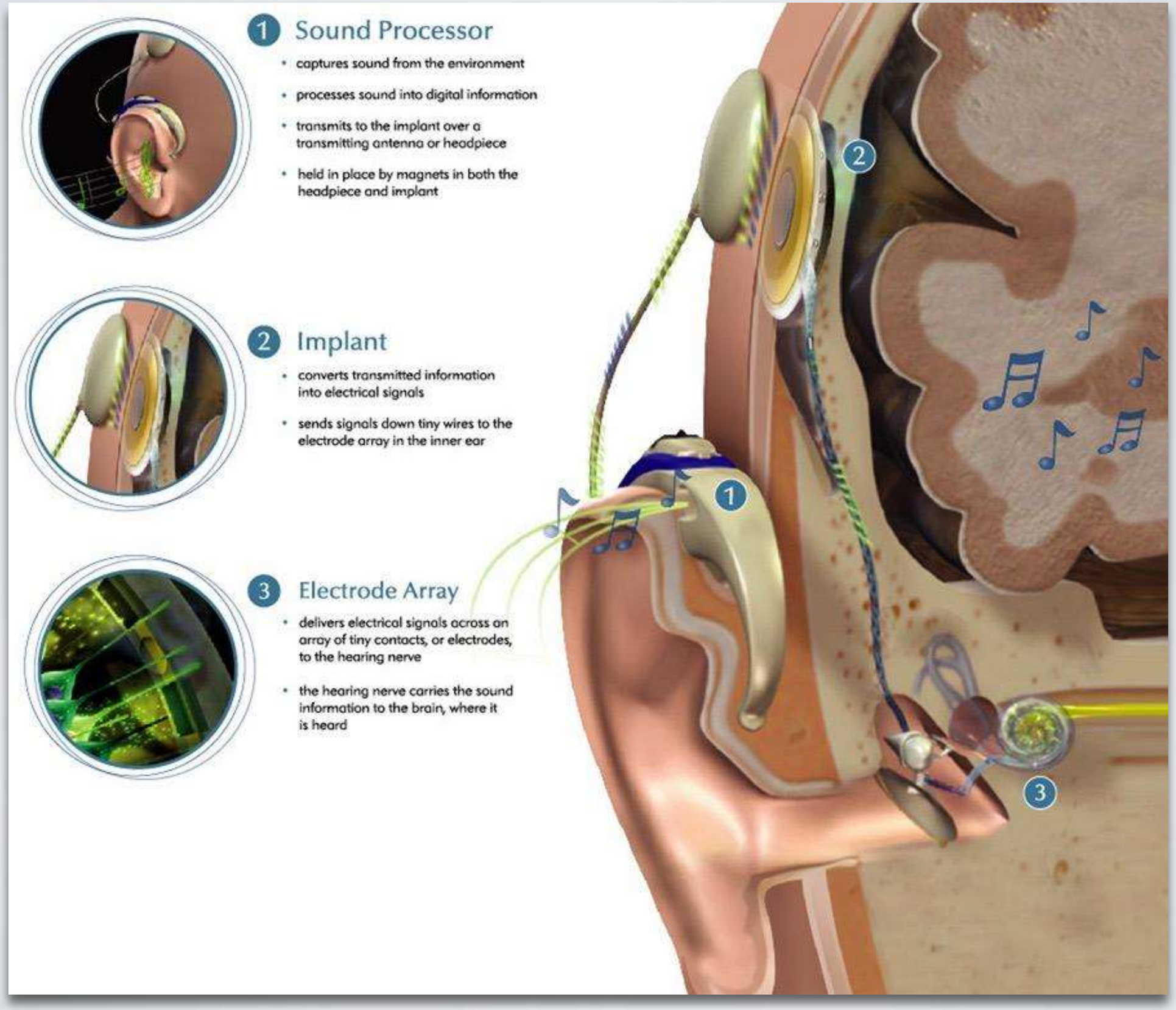


OVERVIEW

1. Introductions
2. Brief History of Cochlear Implants
3. “Bionic Rhetoric”
    - Assistive Technology Design: Normalization vs. Enhancement
4. Bionic Rhetoric in Cultural and Popular Discourse
5. The Future of Assistive Technology

Visualization of a cochlear implant with an electrode array

HOW DOES A COCHLEAR IMPLANT WORK?



COCHLEAR IMPLANTS: A BRIEF HISTORY

- 1925: The “modern” period of electrical hearing begins
- 1952: First electronic hearing aids developed (amplification device)
- 1957: “Monsieur G.” is implanted with an electronic coil in Paris
- 1972: Charles Graser receives first single-channel take home implant from Dr. William House
- 1982: First modern cochlear implants go on the market in Australia (G. Clark introduces the multi-channel Nucleus 22 implant in 1984)
- 1984: FDA approves the 3M single channel cochlear implant for American adults
- 2004: 82,000 worldwide are implanted with the device
- 2007: Bilateral cochlear implantation begins to gain acceptance (approx. 8,000 BCI users)
- 2012: Approximately 324,200 people worldwide have received CIs; in the U.S., roughly 58,000 adults and 38,000 children have been implanted

The original prototype multi-channel cochlear implant

Nucleus 22 multi-channel device

COCHLEAR IMPLANTS: A BRIEF HISTORY

- **From single channel to multiple channels:**
  - The first cochlear implant supplied a single channel, i.e. frequency (first developed in1972).
  - Today, cochlear implants typically supply up to 24 channels.
  - By comparison, hair cells in the cochlea provide thousands of channels.
  - Demo (CI Simulation):

Nucleus 6 System (2014-present)

Kanso (2016-present)

BIONIC RHETORIC

- Historian of Science Mara Mills traces two etymologies for “Bionic”:

(1) Enhancement: coined by Air Force flight surgeon Jack Steel in 1958 to describe the engineering of biological systems based on mechanical principles. Bionics were deployed as a means of designing artificial systems that improve upon biological systems.

- The prosthesis as a “humanitarian” afterthought to radical military advances that made bionics possible.

(2) Normalization: The Maico Company advertised the “Bi-Onic” electrical hearing aid system in 1946.

- “onic” replaced “otic,” to signify “of the ear.” The device was advertised as an auditory prosthesis that mimicked natural hearing.

- As this etymology of bionic suggests, the word inscribes the tension between *enhancement* and *normalization.*

BIONIC RHETORIC & ASSISTIVE TECHNOLOGY

- Up until the 20th century, the emphasis on “treating” hearing loss (and other disabilities) was on *normalization*:
  - The intention of assistive technology was to “correct” or “fix” one’s difference to conform to a normative model of the body/mind.
  - Disability studies scholars and deaf culturalists exposed the potential problems with this viewpoint, citing the negative impact it had on the d/Deaf community.
  - Cochlear’s advertisement for the behind the ear “Kanso”

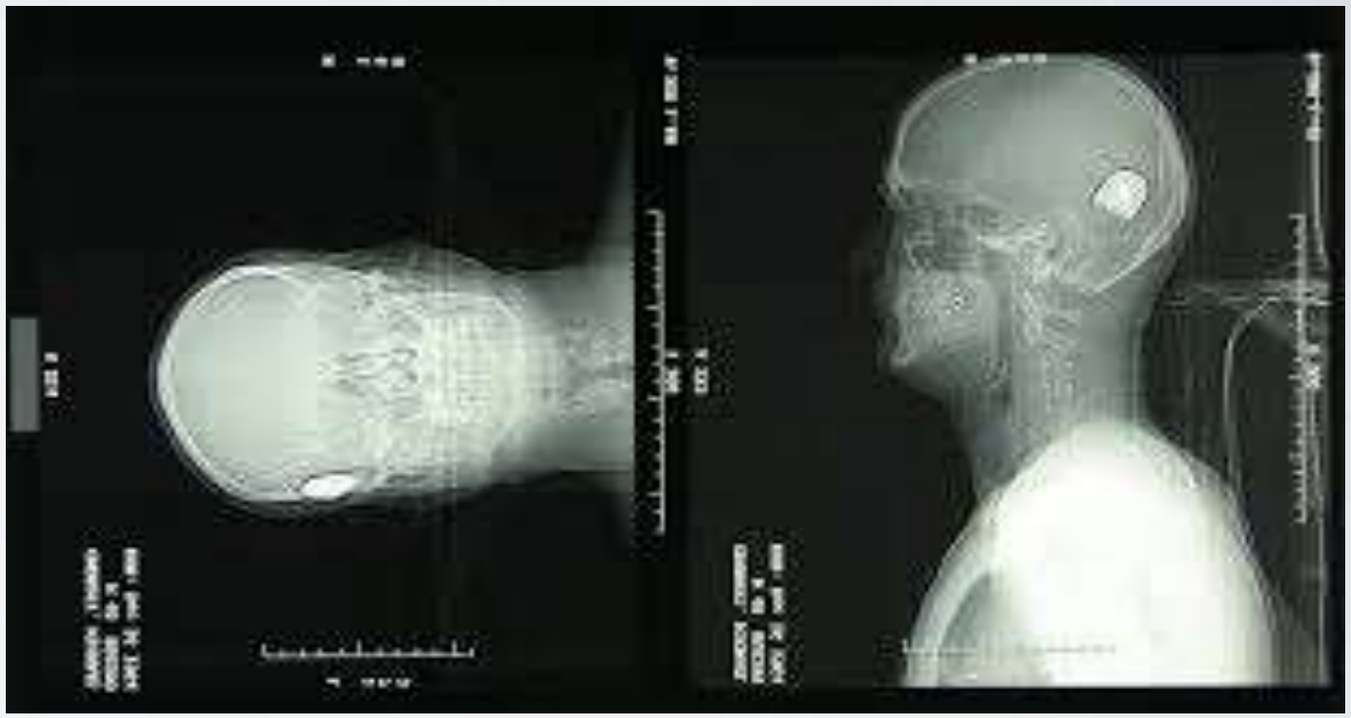
- In the 1950s and 1960s, we see a paradigm shift towards technological *enhancement* with the emergence of computers and cybernetic technologies—this model carried over to biotechnology and assistive technology design.
  - As one of the first neuroprosthetics or brain-computer interfaces (BCIs), cochlear implants became representative of the possibilities of bionic enhancement (improving human performance *beyond* the realm of the “natural” or “normal”).

THE BIONIC RHETORICS OF COCHLEAR IMPLANTS

- **Deaf culture:**
  - Cochlear implants as promoting “Deaficide”—correlated to “language death” of ASL and cultural genocide since 1990s.
  - The documentary film *Sound and Fury* (2000) captures this counterrhetoric, highlighting Deaf culture’s discomfort with CIs as it (1) treats deafness as a disability, and (2) undercuts the centrality and value of silence and nonverbal communication in Deaf culture
- **Bioethicists:**
  - Raise questions about the value of neuroenchancement and artificial prostheses.
  - Bioethicists consider how the CI—as a biomedical/assistive technology—might perpetuate “eugenicist” attempts to promote oralism through the medical eradication of deafness.

THE BIONIC RHETORICS OF COCHLEAR IMPLANTS

- **Deaf Futurists:**
  - deafened individuals (distinct from the Deaf) harness technology to solve communication problems at large.
  - prototype for brain implants, “downloadable intelligence,” and most recently, direct computer-to-brain interfaces
  - Deaf futurists claim that electroacoustic aids bring new sounds and kinds of listening into the world that transcend human ability/biology (Michael Chorost).



X-ray of Michael Chorost post-cochlear implantation

CHOROST'S "BIONIC QUEST"

- Ravel's Bolero: Orchestral sound recording on LP & CD
  - Bolero as auditory benchmark/test : "[Bolero] became my touchstone. Every time I tried out a new hearing aid, I'd check to see if Bolero sounded OK. If it didn't, the hearing aid went back." [Listen]
- Hearing Aids
  - Allowed him to understand speech, but "most music was lost on me. Bolero was one of the few pieces I actually enjoyed."
- Cochlear Implant
  - "In many ways, my hearing was better than it had ever been. Except when I listened to music. I could hear the drums of Bolero just fine. But the other instruments were flat and dull. The flutes and soprano saxophones sounded as though someone had clapped pillows over them. The oboes and violins had become groans. It was like walking color-blind through a Paul Klee exhibit. I played Bolero again and again, hoping that practice would bring it, too, back to life. It didn't."

CHOROST'S "BIONIC QUEST"

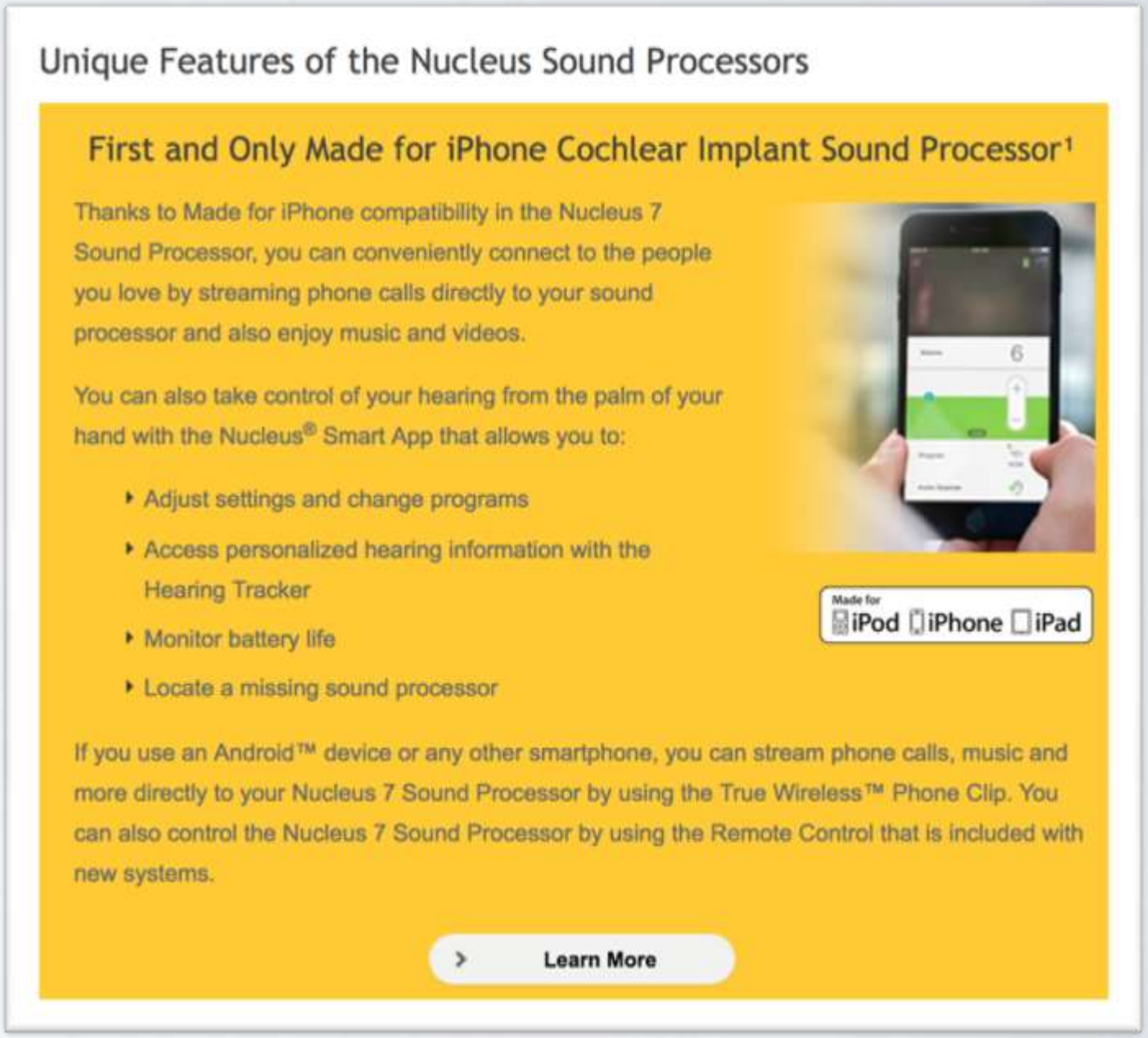
- **"Hacking" the Cochlear Implant: Improving User Experience**
  - Hi-Res
  - Stochastic Resonance: desynchronizing auditory neurons
  - Loizou's team: access to low frequency channels
  - Advanced Bionics: virtual channels (software that makes CI hardware act like there are actually 121 electrodes)
    - "My god, the oboes d'amore do sound richer and warmer. I let out a long slow breath, coasting down a river of sound, waiting for the soprano saxophones and the piccolos. They'll come in around six minutes into the piece—and it's only then that I'll know if I've truly got it back. As it turns out, I couldn't have chosen a better piece of music for testing new implant software….over and over the theme repeats, allowing me to listen for specific details in each cycle."
- What is the trade-off?

DECONSTRUCTING THE ROLE OF ASSISTIVE TECHNOLOGY

- **Cochlear implant as speech processing machine (Mills)**
  - Early investigators of the cochlear implant focused on speech processing.
  - “Engineers don’t program below 250 hertz because it picks up low-pitched sounds (air conditioners, engines) and interferes with speech perception.”
  - “CI signal processors embody a range of cultural and economic values, some of which are deliberately “scripted” into design, others of which accrete inadvertently. These scripts include the privileging of speech over music, direct speech over telecommunication, non tonal languages over tonal ones, quiet ‘listening situations’ over noisy environments, and black-boxed over user-customizable technology” (Mills 323).
- **Cochlear implant as music machine (Chorost)**
  - “After I get over the initial awe of hearing music again, I discover that it’s harder for me to understand ordinary speech than it was before I went to virtual channels.”

DECONSTRUCTING THE ROLE OF ASSISTIVE TECHNOLOGY

- **Cochlear implant as media device**
  - Today, there is virtually no trade-off between music and speech. Due to advances in the software, most cochlear implants can support up to 3-4 programs, which means that users can have a designated program for music, and a designated program for speech (and in different environments: noisy, quiet, and dynamic listening situations with the ability to control microphone sensitivity).
  - Customizable (within certain parameters): most systems come with a *remote control*.
  - Can link to other media devices (TV, mobile phones, iPods, etc.); bluetooth capabilities have been enabled in the newest generation of devices.



HACKING ASSISTIVE TECHNOLOGIES

- “Even without being able to write code themselves, implant users do have a crucial impact on how the code is written. When engineers write new code, they have to test it on implant users to see if it helps them hear better. They also have to find out if implant users like it and can get used to it. To do that they need to recruit articulate users and convince them to offer their time. It’s a highly collaborative process and is integral to how the field makes new advances….My audiologist and I experiment with various parameters during fitting sessions, and it always frustrates me that we only have a few hours in each session to try to find the best values for 20 or more variables. I would love to have the freedom of playing with them on my own. That would considerably accelerate the process. But it is possible in principle to hack one’s own implant. (Michael Chorost blog, comment posted January 5, 2006).

- In the era of computational literacy, we are going to see more users tinkering with their own devices to gain further value or functionality from their devices.