Part VIII Introduction

New Directions: Cochlear Implants

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Thirty years ago we never could have imagined the widespread success that cochlear implants (CIs) have achieved today. Although the sound that is heard by the CI wearer is quite different from what a person with normal hearing perceives, CI users of all ages learn to decipher the electrical signal generated by the CI, and with time are able to (re)gain the ability to understand speech in quiet environments.

For individuals with sensory hearing loss, CIs restore partial hearing through direct electrical stimulation of the auditory nerve, the neural connection between the ear and the parts of the brain involved in the earliest stages of neural processing. Before the acoustic signal is converted to an electrical impulse, it passes through a sound processor. However, the processing strategies that are optimal for speech are not optimal for music, leading to a distorted and atonal signal. It is not surprising then, that music perception and enjoyment decline after implantation. However, now that speech perception ability is approaching near-normal levels, more resources are being devoted to improving music perception through a CI.

In this section entitled "New Directions: Cochlear Implants," we bring together a collection of chapters by Robert Shannon, Sandra Trehub, and Nina Kraus and their respective research teams to represent this relatively new, yet burgeoning field of research. By developing new scientific frameworks to study how music is perceived through a CI, and unlocking how music is represented at the earliest stages of neural processing, we are now on the path to creating more refined CI technology, developing more targeted auditory training programs, and ultimately improving music perception for CI wearers. Broadly speaking, these chapters provide examples for how neuroscience and music research can be unified to bring about new practical and clinical applications.

We begin this section with a chapter from Robert Shannon's group[1] which explores how adult CI listeners perceive melodic pitch. In the next chapter, the focus is on children with CIs, who unlike adult CI listeners are not encumbered by their memory of what music used to sound like. In this chapter, Sandra Trehub and colleagues[2] describe child CI listener's ability to sing and identify familiar songs. We wrap up this section with a chapter from our laboratory[3] that presents a conceptual framework, based on our discoveries of common subcortical processing for speech and music, for assessing CI performance on musical tasks.

A common theme running through this section is that sensory processing is modified by use and experience. Performance is therefore not simply dependent on sensory capacity or the CI device, but draws upon experience-dependent plasticity and top-down (cognitive) processes, such as memory and motivation. This explains, in part, why there is high individual variation in performance among CI wearers, why individuals who engage in music training before or after implantation often exhibit better performance on music discrimination tasks, and why children with implants enjoy listening to and producing music.

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On the basis of this work, and other recent scientific discoveries, we are now in a position to rethink how we define the sensory-cognitive link. From an anatomic standpoint, we know that that the two are inextricably linked via feedforward and feedbackward neural networks between the cochlea and cerebral cortex. So, much in the same way that we can never fully disentangle the roles of nature versus nurture, we need to move away from thinking about sensory and cognitive processes as separable and distinct. Future work on CIs will need to take into consideration how sensory processes dynamically and reciprocally interact with cognitive processes to shape how sound is processed both on an anatomic and on an emotional level.

Despite the fact that speech and music require different processing and listening strategies, we see that improvements in one domain often go hand in hand with improvements in the other. Thus, in re-learning music, or learning it for the first time, CI users (and other impaired listeners) can capitalize on the shared biological resources underlying speech and music processing, and the capacity that music has for shaping our nervous system.

References

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