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Research Paper

The cochlear implant and possibilities for narrowing the remaining gaps between prosthetic and normal hearing



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Abstract Background: The cochlear implant has become the standard of care for severe or **KEYWORDS** worse losses in hearing and indeed has produced the first substantial restoration of a lost or Auditory prosthesis: absent human sense using a medical intervention. However, the devices are not perfect and Cochlear implant; many efforts to narrow the remaining gaps between prosthetic and normal hearing are under-Cochlear prosthesis; way. Deafness; Objective: To assess the present status of cochlear implants and to describe possibilities for Neural prosthesis improving them. *Results*: The present-day devices work well in quiet conditions for the great majority of users. However, not all users have high levels of speech reception in quiet and nearly all users struggle with speech reception in typically noisy acoustic environments. In addition, perception of sounds more complex than speech, such as most music, is generally poor unless residual hearing at low frequencies can be stimulated acoustically in conjunction with the electrical stimuli provided by the implant. Possibilities for improving the present devices include increasing the spatial specificity of neural excitation by reducing masking effects or with new stimulus

modes; prudent pruning of interfering or otherwise detrimental electrodes from the stimulation map; a further relaxation in the criteria for implant candidacy, based on recent evidence from persons with high levels of residual hearing and to allow many more people to benefit

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from cochlear implants; and "top down" or "brain centric" approaches to implant designs and applications.

Conclusions: Progress in the development of the cochlear implant and related treatments has been remarkable but room remains for improvements. The future looks bright as there are multiple promising possibilities for improvements and many talented teams are pursuing them. Copyright © 2017 Chinese Medical Association. Production and hosting by Elsevier B.V. on behalf of KeAi Communications Co., Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Introduction

I had the distinct privilege and honor to present the opening keynote (and plenary) address for the *10th Asia-Pacific Symposium on Cochlear Implants and Related Sciences (APSCI 2015)*, which was held in Beijing from April 30 through May 3, 2015. Some weeks later, Fan-Gang Zeng kindly asked me to contribute a brief synopsis of the lecture for publication in *The Hearing Journal*, which I did.¹ The synopsis (similar to an extended abstract) was indeed short and included only two figures from among the 16 images ("slides" prior to the advent of PowerPoint) that were presented. The purpose of the present paper is to provide a full exposition of the lecture, as it was presented and including nearly all of the figures.

The lecture began with the photo shown here in Fig. 1. With the photo I recalled with the greatest fondness a trip Fan-Gang, Steve Rebscher, Bob Shannon, Gerry Loeb, and I made in 1993 to participate in the *Zhengzhou International Symposium on Electrical Hearing and Linguistics*, which I believe was the first conference of its type in China. Approximately 130 persons attended the conference. Fan-Gang, Steve, Bob, and I are shown in the photo, one that brings back happy memories indeed, including memories of all the wonderful people we met at the conference and our marvelous tour of China afterward.

Everyone in the photo was at the *APSCI 2015*, which was a lovely reunion for us. We noticed that we are a bit younger in the photo!

1993 was at about the time that new and highly effective processing strategies were introduced into clinical practice and after implants with multiple sites of stimulation in the cochlea had been developed. 1993 was near the clear onset of what later would prove to be an exponential growth in the number of implant recipients worldwide, a growth that continues to this day (Fig. 2).

The cochlear implant (CI) is by far the most successful neural prosthesis to date, both in terms of restoration of function and the number of people helped. Indeed, the CI has become the foremost model for the development or



Fig. 1 Fan-Gang Zeng, Steve Rebscher, Bob Shannon, and Blake Wilson in China in 1993.

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