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New System Designed To Improve Hearing In Patients Who Carry A Cochlear Implant

3/4/2008

The doctoral thesis of Isaac Manuel Álvarez Ruiz has been developed in the Departments of Signal Theory, Telematics, and Communication, and Surgery and its Specialties of the University of Granada, and directed by Professors Ángel de la Torre Vega and Manuel Sainz Quevedo. The main aim of this work includes improving the acquisition of Compound Action Potential records, carrying out an application analysis in the cochlear implant programming and studying the distribution of refractory periods for the neuronal population that takes part in the generation of potentials. This doctoral thesis, carried out with the support of the Austrian company Med-El, is very useful for the manufacturers of cochlear implants as the results are a source of information for their present research lines.

The cochlear implant is an electronic device designed to help patients with severe and deep hypoacusis who get very little or no benefit from conventional hearing aids. Patients who use them can detect environmental sounds, most of them are able to understand language with no need of lip-reading, and some of them can even use the phone.

This device is composed of an inner part, implanted surgically, and an outer part. In the inner part we mainly find the stimulus generator and an electrodes-bearing guide inserted all along the cochlea. The outer part is mainly composed of a microphone, a voice processor and a battery unit. So, the signal received by the microphone can be analyzed by the voice processor, which determines the instant in which electrodes should be activated as well as the level of the stimulus.

Specifically
The voice processor in the implant should be specifically programmed for each patient. In order to do so, a programmer performs some subjective tests on the patient. Carrying out this task can get especially hard with children or non-cooperative patients, whose interaction with the programmer is limited or void. So, the search for an objective measurement which provides the automatic programming for the cochlear implant is one of the main research lines opened by the manufacturers. The Compound Action Potential is included in this aim.

The author of this work, Isaac Manuel Álvarez Ruiz, states that “the major difficulty in the recording and processing of the Compound Action Potential is the stimulation device, insomuch that the stimulation signal interferes in time and frequency with the recalled potential that is meant to be observed”. In his thesis, an algorithm has been developed to allow an evaluation of the quality of a Compound Action Potential recording. “This method lets us compare the most commonly used techniques in bibliography, as well as to develop new and improved techniques to reduce the stimulation device”, points out the researcher.

The first task at the time of programming the cochlear implant is to decide which electrodes should be activated and subsequently, establish parameters for each one. So, this research has analyzed the relation between the Compound Action Potential and the cochlear implant voice processor programming map. “We have found that the appearance of the potential generally involves the electrode connection and not vice versa. According to the parameters of each electrode, it has been found that the information provided by these potentials is insufficient for an automatic adjustment of the processor, in comparison with the results of our researches. Our results prove that the Compound Action Potential allows the establishment of parameters of each electrode regarding the average values of the patient, with acceptable uncertainty levels”. This information could be very useful as complementary information, or when the subjective information from the patient is void.

Refractory periods
In addition, a study has been conducted about the distribution of refractory periods for the neuronal population that takes part in the generation of this potential. In the average patient, the value of the refractory period of the fastest neuron is about 0.8ms and half of the neurons have a refractory period lower than 1.5ms. It has been found that, as the auditory experience of the patient increases, the refractory period of the neurons that takes part in it decreases down to a stable value, that is reached 3-4 months after the start up of the voice processor.

The results of this research have resulted in an article titled ‘Generalized alternating stimulation: A novel method to reduce stimulus artifact in electrically-evoked compound action potentials’, published in 2007 in the ‘Journal of Neuroscience Methods’. Other articles are now under review.

SOURCE: Universidad de Granada

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