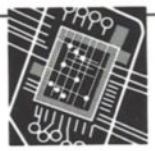
Digitally Programmable Hearing Aids: A Historical Perspective

By Veronica H. Heide, MA

Over 10 years have passed since the inception of Project Phoenix in 1984 which had as its mission the researching and development of a programmable digital hearing instrument and a computer-based hearing test instrument. This article offers the author's retrospective views on the accomplishments of this project.



A joint venture between the University of Wisconsin and Nicolet Instrument Corp., Project Phoenix had as its focus the researching and development of both a hearing instrument which incorporated digital signal processing technology and an advanced computer-based hearing test instrument. The project was initially funded by the Wisconsin Alumni Research Foundation and the Wisconsin State Department of Development and was under the direction of Kurt Hecox, MD, PhD.[1] The project was unique in that it brought together academic researchers in hearing science, neuroscience, psychoacoustics, and engineering (among others) with a manufacturer of medical instrumentation.

Project Phoenix was founded on the beliefs that there are individual differences in hearing loss characteristics and that digital signal processing provided unique ways to manipulate sound that were not possible in an analog device. Concurrent development of both the audiodiagnostic workstation (the Nicolet Aurora) and the digital hearing instrument (the Nicolet Phoenix)was driven by the belief that the development of a valid and reliable hearing aid fitting method for this new technology was just as important as the development of the digital hearing aid. Computer technology provided a flexible platform from which to implement rapid changes in hearing testing, hearing aid fitting protocols, and in the sound processing of both products.[2]

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The audiodiagnostic workstation

The hearing aid fitting was performed using the Aurora which was a 80286 computer-based audiodiagnostic workstation that was designed to test, evaluate, and fit hearing impairment. It had eight modules including Audiometer, Real Ear[3], Hearing Aid Analysis, Hearing Aid Fitting, PC mode and Database. An optional Middle Ear analyzer also was available. Priority was given to the development of the Hearing Aid Fitting module so it would be ready for the launch of a digital hearing instrument.

The Hearing Aid Fitting module simulated what users would experience when they wore the digital hearing instrument, the Phoenix. The hearing aid earpieces (regular and power models) and digital signal processors in both the audiodiagnostic workstation and the hearing instrument were identical to ensure that the sounds heard during the fitting were identical to those the patient would experience while wearing the hearing instrument. Researchers at CUNY and Nicolet both felt that a paired-comparison method would allow patients to reliably converge on their preferences. A Modified Simplex procedure initially was used to find patient preferences for frequency shaping and noise reduction. The Sliding Scale approach was later implemented into the Hearing Aid Fitting module. This module could also be used to fit conventional hearing aids.

Ongoing research in the laboratory and with portable field units evaluated digital signal processing recipes or algorithms for the sound processing that was being considered for the digital hearing instrument. This meant that project resources

were given to the collaborative efforts of the digital signal processing (DSP) engineers, research audiologists, and over 400 hearing-impaired subjects who evaluated these algorithms in the laboratory and in the field.[4]

The three areas initially targeted for improved performance were frequency shaping, loudness limiting, and noise reduction. Following research and field trials, they were added to the Hearing Aid Fitting module of the Aurora and later programmed into the digital hearing instrument based on user preference.

The Two-Piece Hearing Instrument

The first digital signal processing hearing instrument to be introduced in Project Phoenix was a two-piece device (the Nicolet Phoenix) which consisted of a pocket processor connected with a cord to a behind-the-ear instrument. All parts of this instrument were designed with performance and maximum sound quality in mind.

The Nicolet Phoenix BTE that was worn by Larry Peters.

Patients could change the sound processing with three buttons on the pocket processor of the Phoenix. Overall gain was adjusted using a volume control on the earpiece. The function of the three buttons on the pocket processor was defined in software and could be changed to meet patient or performance needs. For example, the three buttons on the pocket processor could be three different programs, or each button could contain multiple programs. Control was in the software instructions.

The BTE Hearing Instrument

In 1989, preparations were being made for the introduction of a one-piece, behind-the-ear model instrument, the Nicolet Phoenix Behind-the-Ear. This instrument housed both analog and digital portions in one behind-the-ear unit. The BTE instrument used a custom integrated circuit that had been developed and was ready for mass production. A user had a switch to select between different programs and a volume control to apply overall gain. The function of the switch could be defined by programming. It ran on three #675 batteries stacked in series in the battery compartment.

The only user in the world to wear the Phoenix BTE was Larry Peters. He wore the instrument continuously for three years without failure. Mr. Peters has reported that "The sound was extremely natural and clear. It had precise definition without distortion of sound, something I have not obtained with other hearing instruments. I was particularly impressed by the noise reduction capability of the instrument. I could push a button and hear in noisy restaurants and groups. This never failed to amaze me!"

An Idea Before Its Time

The two-piece model of the Phoenix had many objections to overcome. In addition to its two-piece configuration, the $2000 price tag was considered formidable in the late 1980s. Although cosmetic objections were addressed by many dispensers who demonstrated the performance benefits of the instrument, consumer attention in that period was primarily focused on canal hearing instruments.

Over $20 million had been invested by Nicolet Instrument Corporation to bring the products developed in Project Phoenix to market. An aggressive search was made for partners outside the stockholders that would invest the funds necessary to mass produce and market the BTE model. When the timeline given by the stockholders was not met, the project was discontinued.

As a member of the project team, I have never viewed Project Phoenix as a failure. The project represented the hearing instrument industry at its best. It provided a method for individualizing the hearing aid fitting using the Nicolet Aurora Hearing Aid Fitting module, and the Phoenix hearing instrument models provided hearing impaired consumers with performance alternatives. Through the project, researchers were encouraged to take their research out of the sound booth and into the real world by combining field trials with laboratory studies. Although Project Phoenix may never rise from the ashes as did its mythological counterpart, it broke new ground and brought to light capabilities and fitting options inherent in digital signal processing instruments. ◆

References

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