EMI to Hearing Aids from Wireless Phones

The evaluation of solutions and the development of standards for hearing aid immunity and phone emissions are the ultimate goals of a recent study.

A. RAVINDRAN, ROBERT E. SCHLEGEL, and HANK GRANT
Wireless EMC Center, University of Oklahoma
Norman, OK

PAMELA MATTHEWS and PERMA SCATES
Hough Ear Institute
Oklahoma City, OK

BACKGROUND

The Center for the Study of Wireless Electromagnetic Compatibility was established at the University of Oklahoma, School of Industrial Engineering, on the Norman Campus in the fall of 1994. Its charter is to work with industry and government to investigate and resolve interaction issues between wireless phones and other electronic devices. The Center began its initial examination of the interaction between wireless phones and hearing aids in May 1995. The Hearing Aid Clinical Study was conducted in cooperation with the Hough Ear Institute in Oklahoma City.

SCOPE OF THE CLINICAL TRIALS

Phase I of the Hearing Aid Study focused on testing 78 people (68 hearing aid users and 10 with unimpaired hearing) to: evaluate the degree of interaction between wireless phones and hearing aids; document the existence and relative interaction as a function of hearing aid type, hearing loss configuration and wireless phone technology; and determine the effectiveness of proposed solutions such as shielding the hearing aid and shielding the phone antenna.

Three phone technologies were studied during the Phase I clinical trials: 1900 MHz PCS (J007), 800 MHz TDMA (IS-54), and 800 MHz CDMA (IS-95), where the numbers in parentheses refer to the particular industry standard for the modulation scheme used.

Two interference measures, *speech recognition* (words identified correctly from a standard audio-taped word list) and *annoyance rating* (quantified on a 0 - 5 scale; 0 indicating no interference; 5 indicating unbearable interference), were used to determine the degree of interaction when hearing aid wearers kept a digital phone at a 2-cm distance (less than 1 inch). Two additional measures, *detection threshold* (the distance at which a hearing aid user detects interference, not necessarily annoying) and *annoyance ratings* at fixed distances between 25 and 300 cm (10 inches to 10 feet), were used to determine the interference to a hearing aid wearer due to bystander use of a wireless phone.

RESULTS

The phones were tested in their worst-case interference mode (at their highest operating power levels) to determine the maximum potential interference. Of course, phones operate at varying power levels, all of which are less severe as an interference source compared to full-power operations. Hence, caution must be exercised in using these results to directly contrast one phone technology with another.

A statistical analysis of the clinical data was performed and the following general conclusions can be drawn from the Phase I results:

- The three phone technologies tested (J007-PCS 1900; IS54-TDMA 800; IS95-CDMA 800) interfered in some, but not all, instances with hearing aids with respect to all four interference measures - speech recognition, annoyance rating at 2 cm, bystander detection threshold, and bystander annoyance ratings (25-300 cm).
- Analog cellular phone tests did not produce any interference.
- Unimpaired hearing participants responded in a very different fashion from hearing aid users in the speech recognition and annoyance tests. Hence, their use as test subjects is inappropriate in examining hearing aid interference, developing standards, and evaluating solutions.
- The following factors have been found to generate statistically reliable differences in interference:
  - phone technology
  - hearing aid type: behind-the-ear (BTE), in-the-ear full shell (ITE), in-the-ear half shell (HS), in-the-canal (ITC), and completely-in-the-canal (CIC)
  - hearing loss configuration: flat, sloping, ski-slope, rising
- The *threshold distance* for 80% of the hearing aid users when they perceived any interference (not necessarily annoying) was less than one meter (3.3 feet) between the hearing aid and the wireless phone.
- On the average, hearing aid users in the study did not experience *annoying interference* (rating of 3 or more) unless the phones were within two feet of the hearing aid. However, the results varied by hearing aid type, hearing loss configuration and phone technology.
- Among the three phone technologies tested in the maximum interference configuration, CDMA phones (IS-95) resulted in lower interference across all measures.
- Among hearing aid types, BTE users experienced the most interference, while ITC users experienced the least interference.
- Among hearing loss configurations, "ski-slope" hearing loss participants experienced the least interference from RF signals.

- Shielding the BTE hearing aids with metallic coating effectively reduced bystander interference at all distances.
- Placing a copper shield between the phone antenna and the hearing aid reduced interference. The technical feasibility and manufacturability of any shielding and its impact on phone and system performance have not been evaluated.

FUTURE RESEARCH

Phase I research focused on evaluating worst-case interaction conditions for hearing aid and phone technologies. Phase II of the Hearing Aid Project involves both instrument-based and hearing aid user testing with an emphasis on identifying the mechanism of the interaction. This should lead to the development of standards for hearing aid immunity and phone emissions, and the evaluation of solutions. Phase II has already begun and is expected to be completed by January 1997. When completed, the study will have evaluated most North American digital phone technologies and types of hearing aids.

A. RAVI RAVINDRAN is the director of the Center for the Study of Wireless Electromagnetic Compatibility and professor of industrial engineering at the University of Oklahoma in Norman. He has a B.S. in electrical engineering from India and an M.S. and Ph.D. in industrial engineering from the University of California at Berkeley. He is a Fellow of the Institute of Industrial Engineers and has published two text books. (405)325-2429.

***ROBERT E. SCHLEGEL, PH.D.**, is a professor of industrial engineering at the University of Oklahoma. His interest in evaluating the interaction of wireless technology with human medical devices is complemented by his research and teaching background in human factors engineering. His work with the OU EMC Center has focused on the development and execution of test protocols for examining wireless interaction with cardiac pacemakers and hearing aids. (405)325-4342.*

***F. HANK GRANT, PH.D.**, is the director of the School of Industrial Engineering and the Southwestern Bell Professor at the University of Oklahoma in Norman. Grant received his doctorate in industrial engineering from Purdue University. He joined OU after serving as the director of the Production Systems and Operations Research Programs for the National Science Foundation. (405)325-3725.*

***PAMELA S. MATTHEWS, M.S.**, has been a clinical and research audiologist at the Hough Ear Institute for seven years. She received her M.S. in audiology from the University of Oklahoma Health Sciences Center in Oklahoma City. Her work with the Hough Ear Institute has focused on technological advances of amplification for the hearing impaired.*

***PERMA S. SCATES, M.S.**, is a clinical and research audiologist with the Hough Ear Institute in Oklahoma City. Perma received her M.S. in audiology at the University of Oklahoma Health Sciences Center in Oklahoma City.*

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