

Stuart Gatehouse: The International Perspective

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The international contributions of Stuart Gatehouse are reviewed in three areas: as a scientist, as an advisor to health policy makers, and as a participant in international conferences. He was able, as no other auditory scientist of his time, to bridge the gap between scientific and clinical research. His ability to apply sound scientific principles to issues of clinical importance

was most apparent in his work in three main areas of his research: acclimatization to amplified speech, auditory disability and hearing aid benefit, and candidature for linear and nonlinear signal processing.

Keywords: acclimatization; auditory disability; hearing aid benefit; candidature for signal processing

A diamond has many facets, each providing a brilliant glimpse of the inner jewel. There are many facets of Stuart Gatehouse's scientific and clinical contributions. Some are well known and others not so well known, but all reveal his central concern of addressing the problem of hearing impairment in a sensible and practical way. The most impressive aspect of his work was his ability to address the core issues from both a scientific and clinical perspective. Stuart was gifted in having this rare ability of bridging the gap between scientific and clinical research.

Stuart's many approaches to the central problem reflect not only a diversity of methods but also a deep understanding of the basic issues. A review of his substantial list of professional publications demonstrates the wide range of his diverse approaches to the problem of hearing impairment. His many publications include studies of monaural and binaural amplification; sound localization; hearing aid fitting procedures; auditory deprivation and acclimatization; bone conduction; psychoacoustics of normal and impaired hearing; auditory ecology and psychoacoustic function as determinants of hearing aid benefit; methods of testing; assessment scales; rehabilitation procedures,

including computer-based techniques, auditory brainstem responses, electrocochleography, electromyography, speech analysis, perception and signal processing, outcome measures, cost-effectiveness of clinical procedures, etiology of hearing loss, incidence of hearing loss, and demographic studies; and reports and advisement to government agencies. His more unusual studies were those of blood viscosity as a factor in sensorineural hearing impairment.

We can view only a few facets of Stuart's remarkable career in this article as our chief concern is the international scope of his many contributions. That scope is broad, and it will be lasting. The capacities in which his influence has been felt most strongly are scientist, scientific advisor to policy makers, and convener of (and contributor to) international conferences.

Gatehouse as Scientist

There is no better way to describe Gatehouse's unique approach to problems than in his own words. In his 2006 curriculum vitae, he wrote that he was interested in the following:

- identifying issues of clinical importance,
- translating the problem into a set of tractable experiments, and then
- formulating the results in terms of clinically applicable recommendations.

This approach resulted in enormously important contributions to the European and North American

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scientific literature, and it was most apparent in three of the areas in which he worked.

Acclimatization to Amplified Speech

Stuart's interest in acclimatization arose partly from the work he did on monaural hearing aid fitting (Swan, Browning, & Gatehouse, 1987; Swan & Gatehouse, 1987a, 1987b). One of the questions provoked by that work was related to the effects of monaural hearing aid fitting on the nonaided ear. In 1989, he published an article in the *Journal of the Acoustical Society of America*, entitled "Apparent Auditory Deprivation Effects of Late Onset: The Role of Presentation Level" (Gatehouse, 1989a) that was the first of several articles in which he identified the issue that speech-identification abilities appeared to improve over a period of time in the ear in which a hearing aid was fitted but not in the unaided ear (Gatehouse, 1990a, 1992). Subsequently, he worked with Ken Robinson to translate the problem into a set of tractable experiments, in this case, to determine the effects of long-term monaural hearing aid use on basic psychoacoustical abilities, such as intensity discrimination and loudness perception (Gatehouse & Robinson, 1995; Robinson & Gatehouse, 1995, 1996). This work, in particular, generated considerable debate among auditory scientists, many of whom embarked on their own work that had become known as *acclimatization*. All this activity culminated in the first Eriksholm Consensus Conference on Auditory Deprivation and Acclimatization, funded by the Oticon Foundation and convened by Stuart in 1995. The papers delivered at that conference, as well as the consensus statement generated by the participants (Arlinger, Gatehouse, & Bentler, 1996), were published in an *Ear & Hearing* supplement edited by Stuart. They remain the primary source of collected information about acclimatization, and in particular, they set the standard for the definition and differentiation of the terms *auditory acclimatization* and *auditory deprivation*. The clinically applicable recommendations eventually manifested them as a fitting method contained in the fitting software of most hearing aid manufacturers that gradually increases high-frequency gain during a period of several months after the initial hearing aid fitting (Gatehouse, 1993). More generally, the realization that hearing aid benefit can change over time has fundamentally changed

how hearing aid efficacy research is done everywhere; almost all studies of this type now include an acclimatization period after the initial fitting before final assessment of benefit is carried out.

Auditory Disability and Hearing Aid Benefit

From the beginning of his interest in hearing aids, Stuart believed that valid measurement of hearing aid benefit—or, for that matter, of benefit from any type of intervention—was an extremely important issue. Earlier, he realized that benefit had to be defined in terms of the effects of intervention on auditory disability. So he translated the problem into a set of experiments that carefully defined dimensions of auditory disability and benefit from auditory habilitation (Day, Browning, & Gatehouse, 1988; Gatehouse, 1989b, 1990b, 1991a, 1991b, 1991c, 1991d, 1994, 1998; Gatehouse & Gordon, 1990; Gatehouse & Swan, 1986; Schow & Gatehouse, 1990; Swan & Gatehouse, 1995). The culmination of this work went considerably beyond the clinically applicable recommendations he had initially envisioned. In 1998 and 1999, the Glasgow Hearing Aid Benefit Profile (GHABP; Gatehouse, 1999a, 1999b) was introduced. The GHABP quickly became a standard instrument for the measurement of hearing aid benefit, filling an urgent need that existed at the time for valid measures of hearing aid outcomes. To date, it has been translated into Catalan, Danish, Dutch, French, German, Italian, Spanish, and Swedish. Subsequent to the release of the GHABP, Stuart went on to contribute many articles to the international literature on the proper construction and use of outcome measures for auditory habilitation (Gatehouse, 2000, 2001, 2003; Gatehouse, Naylor, & Elberling, 2003; Kubba, Swan, & Gatehouse, 2004). Stuart was instrumental in organizing—and was an important participant in—the 1999 Eriksholm Workshop on Measuring Outcomes in Audiological Rehabilitation Using Hearing Aids, during which a blueprint was established for the development of an internationally applicable outcome measure (Cox et al., 2000). That effort eventually resulted in the International Outcome Inventory for Hearing Aids, initially described in 2002 and now available in several languages (Cox & Alexander, 2002; Cox, Alexander, & Beyer, 2003; Cox, Stephens, & Krame, 2002).

Candidature for Linear and Nonlinear Signal Processing

Stuart's interest in hearing aid candidature was a natural outgrowth of his determination to uncover the fundamental connections among factors related to hearing aid use. In this case, the issue of clinical importance was that, although digital hearing aids had made it possible to configure the time and frequency characteristics of hearing aid signal processing in almost all the ways, little was known about how to determine the most appropriate configuration for any given hearing aid user. In the business of translating the problem into a set of tractable experiments, he had Graham Naylor and Claus Elberling as collaborators at the Eriksholm Research Centre. During the course of their collaboration, they completed one of the most ambitious studies ever attempted on the factors (both auditory and nonauditory) related to hearing aid benefit (Gatehouse, Naylor, & Elberling, 2006a, 2006b). Their meticulous work showed that although the configuration and severity of the hearing loss itself are important determinants of the candidature for signal processing, nonauditory factors are also important in predicting the benefit from certain types of signal processing. The culmination that knowing something about the auditory lifestyle of the potential hearing aid user can result in a better hearing aid fitting has been a growing awareness among hearing professionals. In fact, the results of this research on candidature have been incorporated into the fitting software of several major hearing aid manufacturers.

Gatehouse as Advisor to Policy Makers

An important part of Stuart's job as scientist-in-charge of the Scottish Section of the Medical Research Council Institute for Hearing Research was his work on the Institute's National Study of Hearing, which was a multicenter, epidemiological study of acquired hearing impairment and service provision for those with hearing impairment. This work fostered an appreciation in Stuart and some of his colleagues in the Institute for Hearing Research (most notably, Mark Haggard, Quentin Summerfield, and Adrian Davis) of the importance of providing sound scientific data on which government health policy makers could base their decisions. Stuart and his colleagues were responsible for an impressive body of work that provided accurate demographic

data on persons with hearing impairment to the government health agencies of the United Kingdom (Browning & Gatehouse, 1992; Haggard, Gatehouse, & Davis, 1981), and they have served as advisors to health ministries on important issues, such as digital hearing aids for the National Health Service, costs of service delivery, costs of cochlear implantation, and, most recently, benefits of binaural amplification.

Stuart himself was primary author of an influential report concerning "Future of Audiology Services in Scotland," published in 2003. The report described the findings of a study carried out, under the auspices of the Public Health Institute of Scotland, to identify the status of current services in Scotland. The Scottish Executive accepted the report in its entirety, including its recommendations for the investment needed to implement a modernized audiology service in Scotland, and it formed the basis for an ongoing investment in audiology services that has totaled 26 million pounds to date.

Among the important policy advisory positions Stuart held were:

- Member, Department of Health (Scotland) working group on the Future of Hearing Aid Services;
- Member, European Community working group on Advances in Technology for the Hearing Impaired Elderly; and
- Special Advisor to the Scottish Executive Health Department on the development of audiology services in Scotland.

At the time of his death, Stuart was the president of the Internal Collegium of Rehabilitative Audiology (ICRA), an international organization of 50 elected fellows who are active researchers focused on the rehabilitation and habilitation of people with hearing impairment. It is typical of Stuart's commitment to the connection between science and health policy that he had started an ICRA initiative to define benefits of binaural amplification via an international, multisite study. The results of such a study would be very valuable in the establishment of health care policy, especially in countries in which hearing aids are provided by government health care systems.

Gatehouse as Conference Convenor and Contributor

Stuart was keenly aware of the importance of conferences in the formation and fertilization of international connections among scientists. As an

indefatigable traveler, he was to be found behind the podium at almost every major international conference on hearing aids in the past decade, and his paper very often set the standard for the meeting both in quality of content and in sheer exuberance of presentation. A sampling of his conference attendance during the past 2 years of his life reflects his wide-ranging interests and expertise: Aging & Speech Communication, Bloomington, Indiana (October 2005); International Binaural Symposium, Manchester, UK (November 2005); American Academy of Audiology, Minneapolis, Minnesota (March 2006), where he received the International Research Award; and Hearing Care for Adults, Chicago, Illinois (November 2006).

Stuart's organizational influence was exerted most strongly on two recurring international meetings. The two Eriksholm Conferences with which he was most closely connected each produced papers and consensus statements that significantly advanced international progress in auditory deprivation or acclimatization (Arlinger et al., 1996) and in hearing aid outcome measures (Cox et al., 2000). Stuart attended all but the first International Hearing Aid Research Conference (IHCON) held biennially in California in collaboration with House Ear Institute, and he exerted a powerful influence at those meetings. He served as International Co-Chair for the meeting in 2002 and as Technical Chair for the meeting in 2006. His excellent and entertaining presentations, his penetrating questions, and his tireless work in bringing together scientists from different parts of the globe will be profoundly missed at future IHCON's.

The Gatehouse Legacy

The international scope of Gatehouse's contributions is broad and multifaceted. These many facets provide sparkling views of the deep inner brilliance of his work. As a scientist and as a person, Stuart was interested in questions that matter, and he was willing to take on the most difficult ones. As a consequence, he left a significant body of work that will stand as a clear example of how it is possible to bring to bear sound scientific principles on questions of clinical importance and how to apply the results to the development of methodologies that make real differences in the lives of persons with hearing impairment.

By bridging the gap between scientific and clinical research, he was able to make a substantial effect in

addressing the problem of hearing impairment. The many successful inroads that he pioneered and, more important, his vast knowledge and tremendous insight were remarkable. It is said that Gottfried Leibniz was the last person to know everything. With the knowledge explosion, most scientists have honed their expertise so that they know more and more about less and less. Stuart was of a different breed. His knowledge was tremendous, and he did not confine his expertise within narrow boundaries. In this respect, he may have been the last researcher and clinician to have known everything about hearing loss and to have done something useful about it.

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