question. One field of study emerges as an interdisciplinary specialization connected to a discipline (social studies of medicine) a second is labelled as interdisciplinary, even though it functions for all intents and purposes within the university as if it were a discipline (Canadian studies); a third is now generally recognized as a discipline, in spite of the previously divergent methodologies of its practioners (computer music); a fourth has now achieved most of the attributes of a discipline but takes great pride in its interdisciplinary status (environmental studies). An examination of the actions of particular individuals and the organisation of knowledge in specific univerities would also aid in an assessment of the fate of each of these fields of study.

COMPUTER MUSIC AND ACOUSTIC COMMUNICATION: TWO EMERGING INTERDISCIPLINES

Barry Truax

If living in times of great transitions makes life more interesting, then I am twice blessed, for I have been a participant observer over the past two decades in the emergence of two related interdisciplines. Although there is some overlap between them, they are at distinctly different stages of development. The elder of the two, computer music, has grown from modest beginnings in the 1950s as an esoteric offshoot of a general interest in musical applications of technology to its current proliferation as a multimillion dollar industry, on the one hand, and a professional discipline in its own right, on the other. The younger interdiscipline, for which I have coined the term "acoustic communication," has grown out of work in "soundscape studies" by a research group at Simon Fraser University named the World Soundscape Project. It is an example of an "emerging voice" that is attempting to use the framework of communication studies to study phenomena that have largely been ignored in the social sciences. It is clearly still in its infancy and struggling to establish its identity. I propose to sketch a brief life history of each interdiscipline that may illustrate two contrasting lines of development.

Computer music, as the application of digital technology to any and all questions of musical import, traces its beginnings to the pioneering efforts, mainly in the United States, of individuals who were generally scientists or engineers with some degree of musical background, whether amateur or professional. Notable among these was Lejaren Hiller, a chemist and composer, then at the University

of Illinois, who along with Leonard Isaacson programmed the Iliac computer in 1955 to generate output that could be transcribed into music notation. The first results, a string quartet and a book, *Experimental Music,* were greeted with outrage and scepticism, but today this work can be seen to be well grounded within the intellectual climate of the time, which saw, in particular, the emergence of information theory and cybernetics.

The best-known pioneer, Max Mathews, an engineer at Bell Labs and an amateur musician, profited from the invention of the digital-to-analog converter around 1960 (which allowed numbers to be translated into audible sound) and created general-purpose software for producing synthesized music. Since the machines he used were time-shared mainframe computers, the process involved several stages of card punching, number crunching, and transporting the resultant digital tape to a facility housing the converters, a process requiring hours if not days to complete. However, the initial results of Mathews's work included a family of computer music languages (such as MUSIC IV and MUSIC V and their descendents, which established a set of software conventions that have influenced most of the mainstream approaches since), a book, *The Technology of Computer Music* (1969), and a somewhat controversial record, *Music from Mathematics.* This musical output presented everything from well-known tunes to more experimental noise-studies by one of the few composers to work in the Labs in the early years, James Tenney, currently at York University.

My own involvement in the field dates from 1972 when I was a postgraduate student at the Institute of Sonology in Utrecht, which had just acquired a minicomputer (PDP-15). This medium-size computer (having the equivalent dimensions of several refrigerators) was designed for a single user and therefore could be programmed, as in my early POD programs, for interactive compositional work. Although the sound output was limited to monophonic synthesis (external digital oscillators came later), the computer and composer could engage in a "dialogue" about the work in progress. For perhaps the first time, the composer could react to programmed models of musical structure and modify the results quickly, and in addition, the composer's work process could be documented, since the record of the work session could be studied and reproduced. The computer became a compositional assistant as well as a framework for developing new musical ideas.

Five years later the advent of the microcomputer reduced the size and cost of such a system, and five years after that, the commercial musical-instrument manufacturers introduced a communication protocol (musical instrument digital interface, or MIDI) to allow their by now largely digital devices to talk to each other and be controlled by microcomputers. The intervening decade has witnessed the massive growth of personal computers and MIDI-controlled synthesizers. Although today the modes of interaction with the machine are far more elegant, the musical applications far more varied, and the international spread of such systems impressive (unless one laments the loss of regional variations in studios), software remains the weak link in the system.

Viewed as an interdiscipline, computer music can be seen to be propelled by advances in technology and, in particular, by the pressures of the commercial industry that has grown up around it. Yet this is not simply a case of technological determinism, since computers are not merely hardware. The software component ensures that the machine reflects specific knowledge of how to achieve goals, a specific model of how the process is to be carried out, and a desirable range of human behaviour in response to it. In short, the software creates a communicational environment within which the user operates.

But software always carries a paradox within it. On the one hand, to be perceived as useful, it must be flexible and offer the user the illusion of doing "whatever you want"; but at the same time, software systems are "conservative" in that they can only perform what is known well enough to be programmed or what can attract a large enough market. More specifically, the weak link is the way in which user knowledge based on experience with the program is (or is not) channelled back into the software to expand its capabilities. Even though most software appears to be a closed system, there is still the tantalizing, if largely unrealized, potential of its unlimited ability to expand toward new models and systems of unprecedented complexity.

Computer Music Today

The field of computer music today is well established, lively, and flourishing, showing many signs that it has progressed from an emergent interdiscipline to the full maturity (with lingering adolescent traits) of a discipline in its own right. Most of the infrastructure is in place. There is the International Computer Music Association, based in San Francisco with an international board of directors, which sponsors an annual conference that generally alternates between Europe and North America and which in 1993 was held in Japan. The MIT Press publishes the *Computer Music Journal* (CMJ), now nearing twenty volumes. There are regular competitions, juries, commissions, performances, festivals, reviews, publications, degree programs, and so on. Pioneers in the field, most still living, are regularly honoured, there are standard reference works and, perhaps most importantly, there is an international "fraternity" (yes, it is still male dominated). When the editor of the CMJ was asked at a recent conference to define what computer music is, he was inspired to gesture to those around him and say "it's us."

F. Richard Moore, in a recent survey of the field, identified computer music as the intersection of five parent disciplines, namely, music, computer science, engineering, physics, and psychology, with the "inter" disciplines between each pair of fields being AI research, digital hardware, device design, psychoacoustics, and psychomusicology, respectively (1990). Particularly telling is the fact that the younger generation seems to move much more easily between and among these areas, though the ideal of equal competence in hardware, software, music, communication, and cognitive modelling is seldom achieved. However, we have moved a long way from my undergraduate experience in the 1960s, when one felt like a refugee walking between the science building and the music studio! Much of the sense of community seems to stem from the realization that the field is moving so quickly on so many fronts that no single individual can possibly keep up with it all – mutual support seems to be crucial, particularly if one is working locally in relative isolation.

The institutional relations to the "parent" disciplines have largely stabilized as well. Moreover, as these disciplines are increasingly under siege because they produce graduates with traditional training for whom there is a dwindling need, they sometimes merely tolerate, but more frequently welcome, computer music into their curriculum in the hope of adding a veneer of contemporary relevance and student appeal. However, lack of funding for arts education has generally meant that facilities are often unstable, difficult to upgrade, and dependent on cheaper, commercially available equipment intended for a mass market and limited in research potential. Bruce Pennycook, at McGill University, has commented that the university generally has lost its position as the leading edge in the field as a result (1986).

In fact, many computer music studios, particularly in Europe, have thrived apart from either parent discipline, unless absorbed into a music department that is especially well endowed for the purpose. One thinks of CCRMA (the Centre for Computer Research in Music and Acoustics) at Stanford, now housed within the music program but originally independent of it and a "guest" of the AI Lab; or the high-tech Media Lab at MIT; or IRCAM (Institut de Recherche et Coordination Acoustique/Musique) in the Centre Beaubourg in Paris; or the Institute of Sonology, originally semiautonomous within the University of Utrecht, but now affiliated within the Royal Music Conservatory in The Hague. A perennial conundrum in computer music is why there are no major studios in Germany, given the country's leadership in high technology and its strong cultural roots. One telling answer is that there seems to be little institutional support for interdisciplinary work in that country. The tradition is that musicology is taught at the university, composition at the conservatory, technology is fostered by industry, and production studios are housed within the state radio institutions. Even when such institutions are geographically close, there seems to be little tradition of communication or cooperation between them.

In Canada, as in the United States and Britain, work in computer music has, until recently, been almost exclusively associated with the university. However, the recent proliferation of relatively low-cost commercial equipment has produced a corresponding proliferation of computer music in private studios, small artist-run "parallel galleries," and even in secondary and elementary schools. Given the recessionary budgets of most universities, a common cynicism is that the students have more equipment than do the schools. However, research and development remains active in a few universities and in a growing number of small companies seeking out niche markets.

Funding for computer music in Canada is generally acknowledged to lag behind the country's estimable reputation for its electroacoustic music production. Part of the problem is that the field has at various times been perceived to fall between the three granting councils. SSHRC funding has been sporadic but generous, at times supporting research in musical applications, but generally not studio development of software design for composition. The Canada Council (now joined with SSHRC) has targeted its support mainly to artists and arts organizations, and at present has only one grant for research (within the Integrated Media program), which is nonrenewable. It remains to be seen whether the merger of the two councils will result in any increased support for this interdiscipline, which is now so well established internationally.

Acoustic Communication

Compared with the field of computer music, which is widely established, acoustic communication is still merely a "proposed" interdiscipline that has emerged from work in the area at Simon Fraser University. Although acoustic communication relates to the interests of a wide range of scholars and artists, few of them work within a

department of communication or have any other institution or communication network in common.

However, I have attempted in my book *Acoustic Communication* (1984) to give the field an intellectual basis that can be understood as a twofold critique, first, of traditional disciplines that study some aspect of sound and, second, of the social science interdiscipline of communication studies itself. The second critique is based simply on what I have found to be a "blind spot" in the social sciences regarding any subject involving perception. With the traditional disciplines, what is most striking is the way in which the study of sonic phenomena has been fragmented across nearly all areas of academic discourse. Each area proceeds from its own theoretical models and methodology, using its own terms and language, essentially getting the "local picture" correct but ignoring the landscape (or soundscape) as a whole. In addition, and here we see a common thread with the stance of other emerging interdisciplines, acoustic communication finds its justification in the fact that contemporary problems related to sound and audio technology are not well handled by the traditional approaches. Problems such as noise pollution, the impact of the audio industry and the use of sound in media, the apparent decline in listening abilities, and so on, seem insurmountable, except in localized ways, with traditional methodology.

From a theoretical perspective, I have suggested that a new model, one that I call a communicational approach, is needed. The traditional models have been based principally on the notion of energy transfer as found in the physical sciences. Sound and its behaviour is modelled as a series of energy transfers from the source, through the medium, to the receiver, and finally to the brain, ending perhaps with a final emotional dissipation of the energy as annoyance or pleasure. Audio engineering substitutes an analogous series of signal transfers to describe the way in which sound is converted (that is, transduced) from its physical, acoustic form to an electrical signal, then stored, processed, or transmitted, and finally reconstituted at the "receiver's" end. Similarly, classical psychophysics treats the auditory system's processing of incoming stimuli as a series of stimulus-response reactions. Music and linguistics are largely concerned with the internal workings of the phenomena they have defined as within their domain, but most of their theory seems to be based on some kind of linear transmission model, with an emphasis on performance strategies.

The consequences of the base model of each discipline can perhaps best be seen at the level of its corresponding design theory. Acoustical engineering, for instance, when concerned with problems of noise, deals mainly with acoustic energy at the source and in the process of propagation, or else it advocates isolating the receiver or otherwise modifying the sound to minimize unwanted effects. An interesting case of the applied use of psychophysics is the Muzak industry, with all of the attendant controversy surrounding the manipulative use of sound for specific effects on workers and consumers. Architectural acoustics seems caught up in the complexities of achieving good acoustics even in well-defined situations, such as spaces for speech and music transmission; it hardly considers less controlled situations in which quantitative and qualitative criteria have not been agreed upon. And music, which Herbert Simon (1969, 81) calls one of the oldest of the sciences of the artificial, is still largely concerned with matters of musical style, analysis of artifacts (the score), abstract works of art that are thought to exist independent of cultural context, and analytical models that assume an idealized listener that scarcely can exist today given the impact of noise, mass media consumption, and audio consumerism.

The theory of acoustic communication substitutes information for energy or signals as the basic "unit" of its model. Hence, since information is the result of cognitive activity, listening is placed at the centre of the process, not as some final stage of a series of energy/signal transfers. The linear transportation model of signals, in turn, is replaced with the notion of sound as mediating the relationship between listener and environment, where the patterns of influence can proceed in both directions. That is, the communicational situation can be modified, either with a change in the physical environment itself or simply with the listener's perceptual habits. And finally, the notion of context, which is frequently ignored in traditional models, is given a central place in acoustic communication, in the sense that sonic information is dependent both on the nature of the sound itself and on its context.

It is impossible to sketch out all the applications of this new theory, but perhaps it is clear that by being more listener centred and context sensitive, acoustic communication will approach problems in less of a linear "effects" manner and give more emphasis to relationships and processes. In short, it will attempt to deal with the complexities of a communicational situation. It uses all the knowledge garnered from the traditional disciplines, with its validity limited by the assumptions under which it was created, but proposes a larger, more encompassing framework for understanding the contemporary world.

In particular, the model of acoustic communication provides fresh insight into the impact of technology that is so troublesome within

the modern context. Traditional audio theory is based on an assumed neutrality of technology whereby if the transmission of the audio signal is perceived (or measured) to have "fidelity" to the original, then it is thought to have been successful. Besides ignoring any responsibility for content, this model also ignores the inevitable fracture in context – what R.M. Schafer (1977a) terms "schizophonia" – that exists between the original source and its later out-of-context reproduction. A similar philosophy of neutrality is embodied in the use of sound effects that are synchronized to appear "natural" and in emotive music that assumes we all feel the same reaction to a scene (or if not, we will be made to).

Acoustic communication, on the other hand, assumes the inevitable artificiality of the situation, and notes the new relationships (often consumer oriented) that are created by these supposed "extensions" of acoustic phenomena. From a design perspective, the imperative is based less on the manipulative use of sound for its effects and more on an exploration of the sound material itself and ways in which the listener can achieve new levels of understanding of the world through sound. In short, one tries to look past the marketplace hype, which promotes everything as new but instead hides endless repetition of the same, to find situations where technology achieves a net gain in that it changes the process of communication.

Acoustic Communication Today

Acoustic communication will probably not ever have the infrastructure of a discipline in its own right to the extent that computer music has managed in less than forty years. However, it seems to me that communication studies is the proper place to locate it as a field of special study. In order to populate such a field, the intellectual problem I alluded to earlier of the fragmented approach to the study of sound would have to be solved, since this problem translates into a lack of people with sufficient interdisciplinary training. Ideally, we would train students in the social sciences with a sufficient knowledge of acoustics, psychoacoustics, audio technology, and specifically applicable aspects of music, linguistics, audiology, and acoustical engineering. This is clearly a formidable task. Electroacoustic musicians often come closest to this breadth of background, though even with them there are few who can see past a preoccupation with their art to consider applying it to matters of social concern. At the same time, in the "real world" distinctions between media and art, popular and serious music, or media and environment are becoming increasingly blurred and often involve the same technology.

Another possible line of development is for students of acoustic communication to "break into" areas normally open only to graduates of specialized disciplines or to combine communication studies with those disciplines. The advantage such "hybrids" would have, I believe, is a better grasp of how to deal with complex applied problems. Acoustical engineers, for instance, learn all the scientific methodology, but in practice have to deal with government regulation, political imperatives, and individual psychology. Audiologists are trained with the required medical background, but can they communicate with people experiencing hearing loss in a way that makes the implications clear to them? Even more typical is the way in which audio-trained personnel know the technology but have only conventional ideas about how to use it (not to mention frequently having impaired hearing and listening abilities). Fresh ideas could provide a "competitive edge" to anyone entering these fields.

However, it is reasonable to expect resistance to these new ideas from the established disciplines. The World Soundscape Project, cited above as the progenitor of studies in acoustic communication, fortunately began in the late 1960s and early 1970s, directed by R.M. Schafer, at a time when experimentation and interdisciplinary work was, if not in vogue, then at least open to being funded. UNESCO, the Donner Foundation, and SSHRC were some of the sources of public funds used to sponsor field trips across Canada and Europe, the results of which appeared in the group's published documents and recordings. However, by the mid-1970s, sympathy for such experimental work was waning. Schafer left Simon Fraser, and I, as a young, visiting faculty member, had my first experience of an academic "hatchet job" when we applied to SSHRC for a new project involving the study of a village in British Columbia that had been chosen for its acoustic integrity (that is, it was not on a major highway or flightpath) and interest.

SSHRC proposed a site visit and sent out a team comprised of senior academics in geography, physics, and anthropology, along with a junior academic from music. Short-term funding was granted, pending review, but we clearly did not measure up to the reviewers' standards and further funding was curtailed. Whether or not the decision was correct does not matter much now, but what struck me was the vituperation (on paper, at least) of the reviewers, despite the cordial site visit. One in particular even suggested I should be assessed the costs of the reviews! Perhaps they were right; we had no PhDs in any of the established areas, and our methods probably seemed ad hoc. The project disbanded and I went on to do my own research that culminated in the publication of *Acoustic Communication*, which I hope will prove to be a better contribution to the field. But, to my knowledge, the kind of fieldwork that was started has never been done since. I'll always wonder if it was a coincidence that the village we chose (Chemainus) later became famous for its vitality and spirit when it countered the closing of its sawmill with an imaginative mural project that has turned the town into a booming tourist attraction. Was there a correlation between its acoustic cohesiveness and the spirit that later manifested itself?

All new ideas have to fight for survival, but ultimately it may be how well they respond to the needs of the time that determines their longevity. Here, I am convinced that the future of acoustic communication will be bright. Problematic acoustic phenomena are becoming increasingly commonplace and are often complex. The traditional approaches have few answers and even less inclination to adapt their methods to meet the challenge. Public funding is increasingly looking at cost-benefit analysis, and students are voting with their feet by looking at interdisciplinary and applied fields with new interest. And as for the long dormant "soundscapes studies" work at Simon Fraser, much is happening: a new newsletter in several issues with an international mailing list of over 400 people, and at a conference in 1993 entitled the Tuning of the World, a new international organisation, the World Forum for Acoustic Ecology, was formed. Stay tuned!

(RE)PRODUCING INTERDISCIPLINARITY: SOCIAL STUDIES OF MEDICINE AT McGILL

Alberto Cambrosio

In September 1990, I began my new job in the Department of Social Studies of Medicine (SSOM) at McGill University. As can be inferred from its name, this is an interdisciplinary department. Interdisciplinarity was not a new experience for me. My previous position included teaching students of an undergraduate program in science, technology, and society; furthermore, although I had been formally a member of the department of sociology, my office and research activities had been located within the Centre de Recherche en Evaluation Sociale des Technologies, which recruited people from sociology, communication, history, and industrial engineering. My PhD stemmed from an interdisciplinary department, the Institut d'Histoire et Sociopolitique des Sciences of the University of Montreal, where students were exposed to a mix of history and sociology of science and technology, science policy, and epistemology. A postdoctoral