An invention of binaural intra-ear recordings for recording music

Edmund T. Rolls MA, DPhil, DSc, Hon DSc

Oxford Centre for Computational Neuroscience, Oxford, UK www.oxcns.org

and

University of Warwick, Department of Computer Science, Coventry, UK

Recordings of sound from the auditory meatus have been made for some time, often to analyze the effect of the head on sound, and for the development of hearing aids (Paul, 2009). The following describes an invention in 1972 of this method of sound recording for music, the measurements that were made, and how this was demonstrated to the British Broadcasting Company and became the basis for the BBC binaural recordings broadcast for many years.

On 6 May 1972 I attended a lecture at the Oxford Union by Karlheinz Stockhausen on electronic music. That lecture is available on YouTube (Stockhausen, 1972). During the lecture (part 2 of the video), Stockhausen described experiments he had performed on 3D music. He described that at the World Fair at Osaka in Japan he had made recordings in a spherical hall with 600 people on a metal grid across the middle of the inside of the sphere, with loudspeakers all the way round with 7 circles of speakers arranged in 10 columns (not rows!) vertically to create a sound-field above and below the listeners, with sounds coming potentially from any direction of azimuth or elevation. He described how this enabled him to experiment with 3D sound, which he considered an important aspect of electronic music. Stockhausen stated that he greatly regretted not being able to make recordings of the interesting musical effects that he created, because he did not have a 70 channel tape recorder.

This started me thinking. How many channels of sound recording were actually needed? Were 70 channels needed?

I reasoned that all the information from all the locations in space must be present at the tympanic membrane (the ear drum). (I had been a medical student at Cambridge University and knew the anatomy of the auditory system well, and in 1972 was engaged in postdoctoral research in neuroscience at the University of Oxford as a Fellow by Examination at Magdalen College, Oxford.) I reasoned that therefore with a miniature microphone placed in the external auditory meatus close to the tympanic membrane (ear drum), it should be possible to record all the information that could be used by the brain to localize the source of the sound in space.

I tested my hypothesis (I had no idea of any prior work (Paul, 2009)). I purchased some miniature electret microphones made by Knowles that were 2.5x6x7 mm (BL1751 and BL1685), and made recordings with these placed in my external auditory meatus very close to my tympanic membranes. The recordings were spectacular. When played back through headphones, I could localize the sound source to almost anywhere in 3D space. The only slight confusion was between front and

back at 0 degrees of azimuth (i.e. in the horizontal plane). My hypothesis was that the asymmetric, almost helix-like, shape of the human pinna was acting as an asymmetric antenna that was filtering the sound depending on the direction of the sound source in 3D space. I quantified this by making polar frequency response measurements of the human head including the pinna, and published the results in the Journal of Physiology (Rolls, 1973) http://www.oxcns.org/papers/11A_Rolls1973_3DSoundLocalization001.pdf).

I realized the potential for making recordings of music, drama, etc using binaural ear canal recording, for then the exact sound heard by a listener in for example the position of the conductor of a piece of music could be recorded, and played back to the listener, with all the directional and room acoustics faithfully recorded. I therefore registered a UK provisional patent for the method in 1973.

I also contacted the BBC Research Department, and demonstrated the system to members of the BBC Research Department at Kingswood Warren at the invitation of D.J.Meares on, I believe, 19 April 1974. As a result, the BBC broadcast 3D binaural intra-ear sound recordings every week or so for several years.

This recording method, although superb for playback using headphones or earphones, has limitations when listened to through stereo loudspeakers, for then the sound source is less clear, as a second localization occurs for the sound emanating from the loudspeakers. There is a potential solution to this issue, which is the subject of ongoing research in 2017.

Edmund Rolls

Oxford 1 January 2017

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