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Physiology of human voice production revealed by *in-vivo* experiments

C. Julian Chen

Columbia University, jcc2161@columbia.edu

Abstract (250 words)

Scientific knowledge on the physiology of human voice production is the basis for improving voice health as well as diagnosing and treating voice and hearing disorders. According to Max Planck, "Experiments are the only means of knowledge at our disposal. The rest is poetry, imagination." In 1957, French physiologist Philippe Fabre invented the electroglottograph, which can detect the closing and opening of the glottis *in vivo*. In 1984, Donald Miller and Harm Schutte further placed two pressure sensors immediately above and below the glottis. The simultaneously acquired voice, electroglottograph, as well as the subglottal and supraglottal pressure signals *in vivo* composed a comprehensive experimental evidence of human voice production. By analyzing the experimental findings using the wave equation of sound, the following facts are established. First, the source of the acoustic energy of human voice is the kinetic energy of moving air in the vocal tract at the instant of a glottal closing. Second, each decaying acoustic wave triggered by a glottal closing contains full information on the timbre of the voice, therefore called a timbron. A sustained voice is the linear superposition of timbrons triggered by a series of glottal closings. Third, pitch period could be defined as the time interval between two consecutive glottal closings. Based on the timbron theory, a pitch-synchronous voice analysis method and programs are developed, which can be applied to improve voice diagnosis instruments as well as hearing aids with artificial intelligence including controlled frequency shift, noise elimination, and speech enhancement.

Biography (100 words)

C. Julian Chen received a PhD in Physics from Columbia University in 1985, then joined IBM Watson Research Center as a Research Staff Member. He authored *Introduction to Scanning Tunneling Microscopy*, a recognized "bible" of nanoscience. In 1994 he switched research focus to human voice, and then received an Outstanding Innovation Award from IBM in 1998 for breakthroughs in speech technology. In 2007 he joined the Department of Applied Physics and Applied Mathematics of Columbia University, continued basic research on human voice by collaborating with Donald Miller of Groningen Voice Research Laboratory. In 2016 he published *Elements of Human Voice*, a well-received monograph.