Juergen Neubauer

ASSISTANT RESEARCH SCIENTIST
The Laryngeal Dynamics, Physiology, and Speech Production Laboratories
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Education

- 2004: Ph.D. in Physics (Dr. rer. nat), Humboldt University Berlin, Germany
  Thesis: *Nonlinear Dynamics of the Voice: Bifurcations and Mode Analysis of Complex Spatio-Temporal Signals*
- 1998: Diploma in Physics (Masters Degree), University of Bayreuth, Germany

Employment

- 2006 – present: Assistant Research Scientist in the Department of Head and Neck Surgery, David Geffen School of Medicine at the University of California, Los Angeles, USA
- 2004 – 2006: Postdoctoral Research Fellow, The Laryngeal Dynamics Laboratory, Department of Head and Neck Surgery, David Geffen School of Medicine at the University of California, Los Angeles, USA

Grants

- Co-Investigator (key personnel) on NIH R01 grant "Neuromuscular control of the larynx" of Dinesh K. Chhetri (PI), 04/01/2011 – 03/31/2016, direct costs: about 2.5 million dollars
- Principal Investigator (together with Zhaoyan Zhang on a Multiple Principal Investigator grant) of NIH R01 grant "Sound Sources of Phonation", 12/01/2007 – 11/30/2012, direct costs: about 1.5 million dollars
- Co-Investigator (key personnel) on NIH R01 grant "Medial Surface Dynamics of the Vocal Folds" of David A. Berry (PI), 05/01/2002 – 04/30/2012, funding: direct costs: about 1.25 million dollars for each 5 year period
- Investigator on NIH R01 grant "Direct and indirect measures of glottal volume velocity" of Gerald Berke (PI), 07/01/2002 – 06/30/07, direct costs: about 1.25 million dollars

Publications

Journal articles

- D. K. Chhetri, J. Neubauer, J. L. Bergeron, E. Sofer, K. A. Peng, N. Jamal: "Effects of Superior Laryngeal Nerve Asymmetry on Laryngeal Posture, Acoustics and Vibration" Laryngoscope, Submitted (2013)

- G. Chen, J. Kreiman, B. Gerratt, J. Neubauer. Y.-L. Shue, A. Alwan: "Development of a glottal area index that integrates glottal gap size and open quotient", J. Acoust. Soc. Am., In press (2013)

- J. Kreiman, Y.-L. Shue, G. Chen, M. Iseli, B. R. Gerratt, J. Neubauer, A. Alwan: "Variability in the relationships among voice quality, harmonic amplitudes, open quotient, and glottal area waveform shape in sustained phonation", J. Acoust. Soc. Am., 132, 2625–2632 (2012)

- D. K. Chhetri, J. Neubauer, D. A. Berry: "Neuromuscular control of fundamental frequency and glottal posture at phonation onset", J. Acoust. Soc. Am., 131, 1401–1412 (2012)

- D. K. Chhetri, Z. Zhang, J. Neubauer: "Measurement of Young's modulus of vocal folds by indentation", J. Voice, 25, 1–7 (2011)

- Z. Zhang, J. Neubauer: "On the acoustical relevance of supraglottal flow structures to low-frequency voice production", J. Acoust. Soc. Am., 128, EL378–EL383 (2010)

- D. K. Chhetri, J. Neubauer, D. A. Berry: "Graded activation of the intrinsic laryngeal muscles for vocal fold posturing", J. Acoust. Soc. Am., 127, EL127–EL133 (2010)

- J. L. Long, J. Neubauer, Z. Zhang, P. Zuk, G. S. Berke, D. K. Chhetri: "Functional testing of a tissue-engineered vocal fold cover replacement", Otolaryngol. Head Neck Surg., 142, 438–440 (2010)

- Z. Zhang, J. Neubauer, D. A. Berry: "Influence of vocal fold stiffness and acoustic loading on flow-induced vibration of a single-layer vocal fold model", J. Sound Vib., 322, 299–313 (2009)

- G. S. Berke, J. Neubauer, D. A. Berry, M. Ye, D. K. Chhetri: "An ex vivo, perfused larynx model of phonation: a preliminary study", Ann. Otol. Rhinol. Laryngol., 116, 866–870 (2007)

- Z. Zhang, J. Neubauer, D. A. Berry: "Physical mechanisms of phonation onset: A linear stability analysis of an aeroelastic continuum model of phonation", J. Acoust. Soc. Am., 122, 2279–2295 (2007)

- J. Neubauer, Z. Zhang, R. Miraghaie, D. A. Berry: "Coherent structures of the nearfield flow in a self-oscillating physical model of vocal folds", J. Acoust. Soc. Am., 121, 1102–1118 (2007)

- D. A. Berry and Z. Zhang and J. Neubauer: "Mechanisms of irregular vibration in a physical model of the vocal folds", J. Acoust. Soc. Am., 120, EL36–EL42 (2006)
- Z. Zhang, J. Neubauer, D. A. Berry: "Aerodynamically and acoustically-driven modes of vibration in a physical model of the vocal folds", J. Acoust. Soc. Am., 120, 2841–2849 (2006)
- Z. Zhang, J. Neubauer, D. A. Berry: "The influence of subglottal acoustics on laboratory models of phonation", J. Acoust. Soc. Am., 120, 1558–1569 (2006)
- S. L. Thomson, L. Mongeau, S. H. Frankel, J. Neubauer and D. A. Berry: "Self-oscillating laryngeal models for vocal fold research", in Proceedings of the 8th International Conference on Flow-Induced Vibrations, Paris, France, 2, 137–142 (2004)
- J. Neubauer, M. E. Edgerton and H. Herzel: "Nonlinear phenomena in contemporary vocal music", J. Voice, 18, 1–12 (2004)
- M. E. Edgerton, J. Neubauer and H. Herzel: "Using nonlinear phenomena in contemporary musical composition and performance", Perspectives of New Music, 41, 30–65 (2003)
- W. T. Fitch, J. Neubauer and H. Herzel: "Calls out of chaos: The adaptive significance of nonlinear phenomena in mammalian vocal production", Animal Behaviour, 63, 407–418 (2002)
- I. Tokuda, T. Riede, J. Neubauer, M. J. Owren and H. Herzel: "Nonlinear analysis of irregular animal vocalizations", J . Acoust. Soc. Am., 111, 2908–2919 (2002)
- J. Neubauer, P. Mergell, U. Eysholdt and H. Herzel: "Spatio-temporal analysis of irregular vocal fold oscillations: Biphonation due to desynchronization of spatial modes", J. Acoust. Soc. Am., 110, 3179–3192 (2001)

Proceedings papers

- N. Henrich, M. Hess, G. Schade, J. Neubauer, C. Mantay and T. Kirchhoff: "The transillumination technique and its applications : first results", in Proceedings of the 6th International Conference on Advances in Quantitative Laryngology, Voice and Speech Research, Hamburg (2003)
- M. E. Edgerton, J. Neubauer and H. Herzel: "The influence of nonlinear dynamics and the scaling of multidimensional parameter spaces in instrumental, vocal and electronic composition" in Proceedings of the 5th International Conference on Generative Art, Politecnico di Milano University (2001)
- C. Dresel, P. Mergell, J. Neubauer and U. Eysholdt: "Modeling of recurrent nerve paralysis using an analytical description of an asymmetric smooth contour two-mass model", in Proceedings of the 4th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research in Jena, Germany, 2000

Papers in preparation

- J. Neubauer, T. W. Fitch and H. Herzel: "Modeling vocal membranes in bats and primates"
- J. Neubauer, D. K. Chhetri: "Laryngeal posture patterns during neuromuscular stimulation in an in vivo canine larynx"
- J. Neubauer, D. K. Chhetri: "Phonation onset in an asymmetric in vivo canine larynx"
- D. K. Chhetri, J. Neubauer: "Neuromuscular control of fundamental frequency and glottal posture at phonation onset: distal stimulation of laryngeal nerves"
- J. Neubauer, D. K. Chhetri: "Experimental bifurcation analysis in an in vivo model of phonation"
- J. Neubauer, D. K. Chhetri: "Graded stimulation of an in vivo hemilarynx experiment: influence of intrinsic laryngeal muscles on prephonatory vocal fold posturing"
- J. Neubauer, D. K. Chhetri: "Single vocal fold dynamics in graded stimulation in an vivo hemilarynx experiment"
- J. Neubauer, D. K. Chhetri: "Influence of pulse widths in electrical stimulation of TA branch on vocal fold posturing in an in vivo model of phonation"
- J. Neubauer, D. K. Chhetri: "Pressure-flow relationship in single laryngeal muscle stimulation experiments of an in vivo model of phonation"

Conference abstracts

- D. K. Chhetri, J. Neubauer: "Effects of asymmetric vocal fold activation on phonation", J. Acoust. Soc. Am. (ASA Meeting), 127, 2012 (2010)
- Z. Zhang, J. Neubauer: "Experimental observations on the influence of supraglottal flow structures on phonation", J. Acoust. Soc. Am. (ASA Meeting), 126, 2246 (2009)
- D. K. Chhetri, D. Shamouelian, J. Neubauer, Z. Zhang, N. Varshney, G. S. Berke: "Effect of vocal cord height asymmetry on the aerodynamic properties and vibratory pattern of phonation", Western Section Meeting (2008)
- D. Shamouelian, J. Neubauer, Z. Zhang, G. S. Berke, D. K. Chhetri: "Effect of vocal cord height asymmetry on the aerodynamic properties of phonation", Western student medical research forum (2008)
- J. Kreiman, M. Iseli, J. Neubauer, Y.-L. Shue, B. R. Gerratt, A. Alwan: "The relationship between open quotient and H1*H2*", J. Acoust. Soc. Am. (ASA Meeting), 124, 2495 (2008)
- J. Neubauer, Z. Zhang: "On the influence of vocal fold collision on phonation", J. Acoust. Soc. Am. (ASA Meeting), 123, 3742 (2008)

- Z. Zhang, J. Neubauer: "Influence of vocal fold stiffness on phonation characteristics at onset in a bodycover vocal fold model", J. Acoust. Soc. Am. (ASA Meeting), 123, 3578 (2008)
- N. Varshney, J. Neubauer, G. D. Berke, D. K. Chhetri: "Vocal fold height asymmetry and effects on phonation onset and vibratory behavior in excised human larynges", Western Section Meeting (2007)
- Z. Zhang and J. Neubauer and D. A. Berry: "Physical mechanisms of phonation onset: The role of flow instabilities", J. Acoust. Soc. Am. (ASA Meeting), 121, 3121 (2007)
- D. A. Berry and Z. Zhang and J. Neubauer: "Physical mechanisms of phonation onset as revealed by a linear stability analysis of an aeroelastic, continuum model of phonation", PEVOC 7 in Groningen, The Netherlands (2007)
- Z. Zhang and J. Neubauer and D. A. Berry: "Linear stability analysis of an aeroelastic model of phonation", J. Acoust. Soc. Am. (ASA Meeting), 120, 3372 (2006)
- D. A. Berry and J. Neubauer and Z. Zhang "Direct measurement of glottal volume velocity using high-speed, stereoscopic, particle imaging velocimetry", J. Acoust. Soc. Am. (ASA Meeting), 120, 3354 (2006)
- J. Neubauer and Z. Zhang and D. A. Berry: "Coherent glottal flow structures in the nearfield of a physical model of vocal folds", 5th ICVPB in Tokyo, Japan, 2006
- H.-P. Herzel and R. Zaccarelli and T. Riede and J. Neubauer and W. T. Fitch: "Nonlinear phenomena in vertebrate vocal production", J. Acoust. Soc. Am. (ASA Meeting), 120, 3189 (2006)
- J. Neubauer, Z. Zhang and D. A. Berry: "Observations of the near-field structures of the glottal flow", J. Acoust. Soc. Am. (ASA Meeting), 118, 2026 (2005)
- D. A. Berry, Z. Zhang and J. Neubauer: "Mucosal wave velocity", J. Acoust. Soc. Am. (ASA Meeting), 118, 2026 (2005)
- J. Neubauer, Z. Zhang and D. A. Berry: "Effects of subglottal acoustics on phonation onset", J. Acoust. Soc. Am. (ASA Meeting), 117, 2542 (2005)
- J. Neubauer, R. Miraghaie and D. A. Berry: "Dynamics of coherent flow structures of a pulsating unsteady glottal jet in human phonation", Proceedings of the 57th Annual Meeting of the Division of Fluid Dynamics, American Physical Society, Seattle, 2004
- M. Doellinger, J. Neubauer and D. A. Berry: "Quantitative measurement of the medial surface dynamics of the vocal folds using high-speed digital imaging", J. Acoust. Soc. Am. (ASA Meeting), 114, 2459 (2003)
- J. Neubauer, T. Fitch and H. Herzel: "Modeling dynamical effects of local morphological changes of vocal folds", Forum Acusticum 2002 in Sevilla, Spain, 2002

- J. Neubauer, T. Fitch and H. Herzel: "Modeling the role of vocal membranes in bats and primates: Dynamical Effects of local morphological changes of vocal folds", 3rd ICVPB in Denver, USA, 2002
- J. Neubauer, P. Mergell and H. Herzel: "Spatio-temporal analysis of biphonic phonation revealing desynchronization of spatial modes", Presentation at UCLA, Los Angeles, USA, 2002
- J. Neubauer, T. W. Fitch and H. Herzel: "Nonlinear Dynamics of the Voice - Modeling the Role of Vocal Membranes in Bats and Primates", Poster for Dynamics Days Europe 2002 in Heidelberg, Germany
- J. Neubauer and H. Herzel: "Nonlinear Dynamics of the Voice – Bifurcation and Mode Analysis", Final Colloquium of the Institute for Theoretical Biology 2001
- J. Neubauer, P. Mergell and H. Herzel: "Spatio-Temporal Analysis of Biphonic Phonation of Spatial Modes", PEVOC IV in Stockholm, Sweden, 2001
- J. Neubauer, T. W. Fitch and H. Herzel: "Modeling Dynamical Effects of Local Morphological Changes of Vocal Folds", 5th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research in Groningen, Netherlands, 2001
- J. Neubauer and P. Mergell: "Extraction and Analysis of Spatio-Temporal Glottal Contour Patterns: High-Speed Glottography and Nonlinear Dynamics", 4th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research in Jena, Germany, 2000
- J. Neubauer, P. Mergell, H. Herzel, M. Tigges, T. Wittenberg and U. Eysholdt: "High-Speed Observations and Biomechanical Modeling of Asymmetry of Vocal Fold Motion", International Workshop on Models and Analysis of Vocal Emissions for Biomedical Applications in Florence, Italy, 1999

Research

Areas of expertise

- Nonlinear dynamics and nonlinear phenomena (time series analysis) in mammalian voice production, in particular the influence of asymmetries on dynamics of coupled oscillators in mammalian phonatory systems
- Neurophysiology of the human larynx, in particular graded electrical stimulation of intrinsic laryngeal muscles for experimental bifurcation analysis of in vivo models of phonation
- Characterization of mechanical properties of in vitro and laboratory models of human vocal folds: Visco-elasticity of soft tissue
- Aeroacoustics, physiology and biomechanics of normal and pathological mammalian vocalizations

- Biomechanical modeling of normal and pathological human phonation

Current Projects

- 2009 – present: Selective laryngeal nerve stimulation in in vivo dog models for studies of vocal fold dynamics (collaboration with D. K. Chhetri, and D. A. Berry, UCLA, USA)
- 2003 – present: Aeroacoustics of Voice Production: Source-tract interaction in phonation (collaboration with Z. Zhang, and D. A. Berry, UCLA, USA)
- 2003 – present: Modal analysis of complex spatio-temporal signals from the medial surface of vocal folds (collaboration with Z. Zhang and D. A. Berry (PI of NIH grant), UCLA, USA)
- 2003 – present: Finite Element modeling of vocal fold vibration and glottal fluid-structure interaction (collaboration with Z. Zhang and D. A. Berry, UCLA, USA)

Completed Projects

- 2006 – 2009: Mechanical characterization of excised vocal folds and physical models of vocal folds with indentation (collaboration with Z. Zhang, D. K. Chhetri, E. Goodyer, UCLA, USA)
- 2001 – 2003: High speed endoscopic visualization of phonation in primates (collaboration with O. Larsen, Odense, Denmark, T. W. Fitch, Harvard University, Cambridge MA, and H. Herzel, Institute for Theoretical Biology, Berlin, Germany)
- 2002 – 2003: Combining EGG measurements, transillumination endoscopy and high speed glottography (collaboration with N. Henrich, KTH Stockholm, Sweden, and M. Hess, Hamburg)
- 2001 – 2003: Extra-complex sonorities in vocal improvisers (collaboration with M. E. Edgerton, Berlin)
- 2001 – 2003: Computer modeling of vertebrate vocal production (collaboration with H. Herzel, Institute for Theoretical Biology, Berlin, Germany, and T. W. Fitch, Harvard University, Cambridge, MA)
- 2001 – 2002: Nonlinear dynamics of contemporary vocal music (collaboration with H. Herzel and M. E. Edgerton, Berlin)
- 2000 – 2001: Time series analysis and vibration pattern classification in high speed observations of voice patients (collaboration with P. Mergell, U. Eysholdt, Erlangen, Germany, and H. Herzel, Berlin)
- 1999 – 2000: Biomechanical modeling of pathological phonation, High speed glottography of pathological phonation (collaboration with M. Tigges, P. Mergell, T. Wittenberg, U. Eysholdt, Erlangen, Germany, and H. Herzel, Berlin)

Professional Activities

Teaching

- Computer tutorial (teaching assistant) in 'Nonlinear Dynamics and Time Series Analysis' for biology students, 2001–2002, Humboldt University Berlin, Germany
- Teaching Assistant for Mathematics for undergraduate biology students, 2001–2002, Humboldt University Berlin, Germany
- Teaching Assistant for Theoretical Physics for undergraduate physics students, 1997–1998, University of Bayreuth, Germany

Mentoring

- Supervision of Summer Student Research Projects: "Vocal fold height asymmetry and effects on phonation onset and vibratory behavior in excised human larynges", N. Varshney, J. Neubauer, G. S. Berke, D. K. Chhetri (2006); "Effect of vocal cord height asymmetry on the aerodynamic properties of phonation", D. Shamouelian, J. Neubauer, Z. Zhang, G. S. Berke, D. K. Chhetri (2007)

Reviewer for Professional Journals

- Zeitschrift für Medizinische Physik
- Zeitschrift für Audiologie
- Folia Phoniatrica et Logopaedica
- Journal of the Acoustical Society of America
- Journal of the Royal Society Interface
- Journal of Speech, Language, and Hearing Research
- International Journal of Heat and Fluid Flow
- Annals of Biomedical Engineering
- PloS Computational Biology
- Journal of Biomechanics
- Biomechanics and Modeling in Mechanobiology
- Medical and Biological Engineering and Computing

Presentations

- D. K. Chhetri, D. Shamouelian, J. Neubauer, Z. Zhang, N. Varshney, G. S. Berke: "Effect of vocal cord height asymmetry on the aerodynamic properties and vibratory pattern of phonation", Western Section Meeting, 2008
- D. Shamouelian, J. Neubauer, Z. Zhang, G. S. Berke, D. K. Chhetri: "Effect of vocal cord height asymmetry on the aerodynamic properties of phonation", Western Student Medical Research Forum, 2008
- N. Varshney, J. Neubauer, G. D. Berke, D. K. Chhetri: "Vocal fold height asymmetry and effects on phonation onset and vibratory behavior in excised human larynges", Western Section Meeting, 2007
- D. A. Berry and Z. Zhang and J. Neubauer: "Physical mechanisms of phonation onset as revealed by a linear stability analysis of an aeroelastic, continuum model of phonation", PEVOC 7 in Groningen, The Netherlands, 2007
- J. Neubauer and Z. Zhang and D. A. Berry: "Coherent glottal flow structures in the nearfield of a physical model of vocal folds", 5th ICVPB, Tokyo, Japan, 2006
- J. Neubauer, R. Miraghaie and D. A. Berry: "Dynamics of coherent flow structures of a pulsating unsteady glottal jet in human phonation", Proceedings of the 57th Annual Meeting of the Division of Fluid Dynamics, American Physical Society, Seattle, 2004
- N. Henrich, M. Hess, G. Schade, J. Neubauer, C. Mantay and T. Kirchhoff: "The transillumination technique and its applications: first results", 6th International Conference on Advances in Quantitative Laryngology, Voice and Speech Research, Hamburg, 2003
- J. Neubauer, T. Fitch and H. Herzel: "Modeling dynamical effects of local morphological changes of vocal folds", Forum Acusticum 2002, Sevilla, Spain, 2002
- J. Neubauer, T. Fitch and H. Herzel: "Modeling the role of vocal membranes in bats and primates: Dynamical Effects of local morphological changes of vocal folds", 3rd ICVPB, Denver, USA, 2002
- J. Neubauer, P. Mergell and H. Herzel: "Spatio-temporal analysis of biphonic phonation revealing desynchronization of spatial modes", Presentation at The Laryngeal Dynamics Laboratory, David Geffen School of Medicine at UCLA, Los Angeles, USA, 2002
- J. Neubauer, T. W. Fitch and H. Herzel: "Nonlinear Dynamics of the Voice - Modeling the Role of Vocal Membranes in Bats and Primates", Poster for Dynamics Days Europe, Heidelberg, Germany, 2002
- J. Neubauer and H. Herzel: "Nonlinear Dynamics of the Voice – Bifurcation and Mode Analysis", Final Colloquium of the Institute for Theoretical Biology, Humboldt University Berlin, Germany, 2001

- J. Neubauer, P. Mergell and H. Herzel: "Spatio-Temporal Analysis of Biphonic Phonation of Spatial Modes", PEVOC IV, Stockholm, Sweden, 2001
- J. Neubauer, T. W. Fitch and H. Herzel: "Modeling Dynamical Effects of Local Morphological Changes of Vocal Folds", 5th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research, Groningen, Netherlands, 2001
- C. Dresel, P. Mergell, J. Neubauer and U. Eysholdt: "Modeling of recurrent nerve paralysis using an analytical description of an asymmetric smooth contour two-mass model", 4th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research, Jena, Germany, 2000
- J. Neubauer and P. Mergell: "Extraction and Analysis of Spatio-Temporal Glottal Contour Patterns: High-Speed Glottography and Nonlinear Dynamics", 4th International Workshop on Advances in Quantitative Laryngoscopy, Voice and Speech Research, Jena, Germany, 2000
- J. Neubauer, P. Mergell, H. Herzel, M. Tigges, T. Wittenberg and U. Eysholdt: "High-Speed Observations and Biomechanical Modeling of Asymmetry of Vocal Fold Motion", International Workshop on Models and Analysis of Vocal Emissions for Biomedical Application, Florence, Italy, 1999

Previous work experience

- 2003 – 2004: Staff Research Associate, The Laryngeal Dynamics Laboratory, Division of Head and Neck Surgery, David Geffen School of Medicine at UCLA
- 2000 – 2003: Research Assistant, Institute for Theoretical Biology, Humboldt University Berlin, Germany
- 1999 – 2000: Research Assistant, Department of Phoniatrics and Pediatric Audiology, ENT Hospital Erlangen, Germany,
- 1994 – 1998: Sound Engineer for several semi-professional bands in Bayreuth
- 1997: Summer student internship at Max-Planck Institute for Plasma Physics in Munich, Germany, in the department of Thomson scattering,
- 1996: Summer internship at sound recording studio in Bayreuth, Germany
- 1995: Summer internship at Siemens Research Center in Erlangen, Germany, in the department of Research and Development
- 1994: Summer student internship at consulting company for construction physics, acoustics and technical vibrations in Bayreuth, Germany

Computer Skills

- Linux, scientific Linux applications
- Programming and text processing languages: Python (including Numpy, SciPy, Matplotlib, ctypes, PyCUDA, OpenCV, pyTDMS, Django), LabVIEW, Matlab, Bash, C, Fortran, Maple, HTML, JavaScript, LaTeX, Pascal, Basic
- Numerical analysis of dynamical systems: XPPaut, Tisean, PyDSTool
- Image processing and computer vision: OpenCV, PyCUDA
- Computational fluid dynamics: OpenFOAM, pythonFlu, Salome, enGrid, tetgen, netgen, gmsh, ParaView, ADINA
- Microsoft Windows, scientific Windows applications; Mac OSX

Language Skills

- English and German (fluent speaking and reading knowledge)

Personal Details

- Date of Birth: October 18, 1972 in Pegnitz, Germany

Interests

History of Physics in the 20th Century, Sound engineering, Psychoacoustics, Percussion, Marathon running, Road bicycling, Ironman triathlon, Squash, Badminton