# BIOGRAPHICAL SKETCH

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NAME: Juchem, Christoph

eRA COMMONS USER NAME (credential, e.g., agency login): CJUCHEM

POSITION TITLE: Associate Professor, Departments of Biomedical Engineering and Radiology

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

| INSTITUTION AND LOCATION | DEGREE *(if applicable)* | Completion Date MM/YYYY | FIELD OF STUDY |
|---|---|---|---|
| University of Bonn, Germany | | 1995-1997 | Physics |
| University of Madrid, Spain | | 1997-1998 | Physics |
| University of Bonn, Germany | M.Sc. | 1998-2001 | Physics |
| Max-Planck Institute for Biological Cybernetics, Tübingen, Germany | Ph.D. | 2001-2006 | MR Physics / Neuroscience |
| Yale University, New Haven, CT, USA | PostDoc | 2007-2008 | MR Physics / MR Spectroscopy |

### A. Personal Statement

I am Associate Professor in the Departments of Biomedical Engineering and Radiology at Columbia University. In my research, I develop novel magnetic resonance methods and technology to establish optimized tools for neuroscientific and clinical applications. My long-term goal as a physicist is to realize the full potential of magnetic resonance spectroscopy (MRS) as a diagnostic tool. My clinical long-term goal is to understand the role that neurochemicals play in the protection of the human central nervous system (CNS) or, alternatively, how dysfunction promotes vulnerability towards neurodegenerative and neuro-immunological diseases.

Reliable quantification of biochemicals with *in vivo* MRS relies on excellent spectral data quality, processing and quantification capability. In my research, I have optimized critical aspects of the measurement pipeline including experimental conditions (e.g. B0 shimming), MRS sequences (e.g. ‘ghost’ removal) and quantification (e.g. simulation of realistic basis spectra for linear combination modeling). I furthermore developed and disseminated the freeware INSPECTOR user-tool as a one-stop-shop solution for processing, quantification and quality assessment of *in vivo* MRS data (200+ downloads since 2017).

I have 20 years of experience in developing and conducting *in vivo* MR experiments at 3.0-11.7 Tesla field in humans and animal models and have demonstrated my scientific expertise in 50+ publications, book chapters and patents, as reviewer for 20+ scientific journals and as grant reviewer for 8 national research societies. I served as Co-Director of Yale University's 7T Brain MR Spectroscopy Core, Chair of the ISMRM Engineering Study group, member of the ISMRM Annual Meeting Program Committee (AMPC). I serve on the editorial board of *NMR in Biomedicine* and as Secretary of the ISMRM MR Spectroscopy Study Group, to be Chair in 2023.

1. Landheer, K., Swanberg, K.M., **Juchem, C.** (2021). Magnetic resonance spectrum simulator (MARSS), a novel software package for fast and computationally efficient basis set simulation, *NMR Biomed.* 34:e4129. PMID: 3131877 (*Cover Image of Special Issue*)
2. Landheer, K., **Juchem, C.** (2021). Are Cramer-Rao lower bounds an accurate estimate for standard deviations in in vivo magnetic resonance spectroscopy? *NMR Biomed.* 34:e4129. PMID: 33876459 (*Cover Image*)

3. Landheer, K., Gajdosik, M, Treacy, M, **Juchem, C.** (2020). Concentration and effective T2 relaxation times of macromolecules at 3T, *Magn. Reson. Med.* 84:2327-2337. PMID: 32430924 (*Editor's Pick*)
4. **Juchem, C**., Theilenberg, S, Kumaragamage, C., Mullen, M., DelaBarre, L., Adriany, G., Brown, P.B., McIntyre, S., Nixon, T.W., Garwood, M., de Graaf, R.A. (2020). Dynamic Multi-Coil Technique (DYNAMITE) MRI on human brain. *Magn Reson Med* 84:2953-2963. PMCID: PMC8168279 (*Editor's Pick*)

**B. Positions and Honors**

**Positions and Employment**

| | |
|---|---|
| 1995-1997 | Studies of Physics, Rheinische Friedrich-Wilhelms University of Bonn, Germany |
| 1997-1998 | Studies of Physics, Universidad Autónoma de Madrid, Spain |
| 1998-2001 | Studies of Physics, Rheinische Friedrich-Wilhelms University of Bonn, Germany |
| 2000-2001 | Night operator at the particle accelerator of the University of Bonn, Bonn Isochron-Cyclotron |
| 2002-2006 | Doctoral Studies, Max-Planck Institute for Biological Cybernetics and Eberhard-Karls University of Tübingen, Tübingen, Germany |
| 2007-2008 | Postdoctoral Associate, Yale MR Research Center, Dept. Diagnostic Radiology |
| 2008-2011 | Associate Research Scientist, Yale MR Research Center, Dept. Diagnostic Radiology |
| 2010-2016 | System manager human 7 Tesla MR scanner, Yale MRRC, Dept. Diagnostic Radiology |
| 2010-2016 | Co-director of the 7 Tesla brain MR spectroscopy core at Yale MRRC, Dept. Diagn. Radiology |
| 2012-2016 | Assistant Professor, Departments of Radiology & Neurology, Yale University |
| **2016-Present** | **Associate Professor (Tenure Track), Departments of Biomedical Engineering & Radiology, Columbia University** |
| 2017 | Visiting Professor, Comprehensive Heart Failure Center, University Hospital Würzburg, Germany |
| 2018-Present | Adjunct Faculty, Icahn School of Medicine at Mount Sinai (ISMMS), New York |
| 2019-Present | Affiliate Member, Zuckerman Mind Brain Behavior Institute (ZMBBI), Columbia University |

**Other Experience and Professional Memberships**

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|---|---|
| 2002-Present | Member, DS-ISMRM (German Section of the ISMRM) |
| 2004-Present | Member, International Society for Magnetic Resonance in Medicine (ISMRM) |
| 2007-Present | Member, German Physical Society (DPG) |
| 2008-Present | Member, MR Engineering Study Group, ISMRM |
| 2014-2015 | Member, Workshop and Study Group Review Committee, ISMRM |
| 2016-Present | Member, Institute of Electrical and Electronics Engineers (IEEE) |
| 2016-2019 | Member, ISMRM Annual Meeting Program Committee (AMPC) |

*Journal Reviewer*: 1) European Journal of Neuroscience, 2) Magnetic Resonance in Medicine, 3) Journal of Magnetic Resonance, 4) Nuclear Magnetic Resonance in Biomedicine, 5) Concepts in Magnetic Resonance A, 6) Biological Psychiatry, 7) Neurobiology of Aging, 8) Analytical Biochemistry, 9) Public Library of Science, 10) Magnetic Resonance Materials in Physics, Biology and Medicine, 11) IEEE Transactions on Biomedical Engineering, 12) IEEE Transactions on Applied Superconductivity, 13) Human Brain Mapping, 14) Magnetic Resonance Imaging, 15) Tomography, 16) Journal of MR Imaging, 17) Medical Physics, 18) Multiple Sclerosis Journal, 19) NeuroImage, 20) Neuropsychopharmacology, 21) Neurology

*Editorial Board*: 1) NMR in Biomedicine

*Grant Reviewer*: 1) Dutch National Research Society (NWO), 2) Dutch Technology Foundation (STW), 3) Research Foundation Flanders (FWO), 4) National Multiple Sclerosis Society (NMSS) / USA, 5) Multiple Sclerosis Society / United Kingdom, 6) Israel Science Foundation (ISF), 7) German Science Foundation (DFG), 8) National Institutes of Health (NIH, *Ad hoc*: EITN, SBIB-T, ITD, IGIS)

**Honors**

| | |
|---|---|
| 1997-1998 | Erasmus Exchange Fellowship of the European Union |
| 2004-06 | 3 ISMRM educational stipends, Annual Meetings: Kyoto/Japan, Miami Beach/FL, Seattle/WA |

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|---|---|
| 2006 | Doctoral stipend of the Max-Planck Society |
| 2007-2008 | J.H. Brown & A. Brown Coxe postdoctoral fellowship in the medical sciences, Yale University |
| 2010 | Best scientific poster in engineering, ISMRM Annual Meeting, Stockholm, Sweden |
| 2011 | Stipend of the German Scholars Organization (GSO) |
| 2011 | I.I. Rabi Young Investigator Award finalist, ISMRM Annual Meeting, Montreal, Canada |
| 2012-2013 | Secretary, MR Engineering Study Group, ISMRM |
| 2013 | Clinical and Translational Science Award (CTSA), Yale Center for Clinical Investigation (YCCI) |
| 2013-2014 | Vice-Chair, MR Engineering Study Group, ISMRM |
| 2014-2015 | Chair, MR Engineering Study Group, ISMRM |
| 2014-2018 | Distinguished Reviewer (5x), Magnetic Resonance in Medicine (MRM) |
| 2021-2022 | Secretary, MR Spectroscopy Study Group, ISMRM |

## C. Contribution to Science

### 1. Optimized experimental conditions and methods for clinical MR spectroscopy.

The best experimental conditions and MRS methods are a necessity for excellent spectral quality and meaningful biochemical profiling with MRS - not a choice. In my research, I developed innovative $B_0$ shimming techniques tailored to MRS applications in the animal and human brain. My lab was the first to show that spectra free of 'ghosting' artifacts can be predictably obtained for virtually any experiment type with numerically optimized suppression of unwanted coherence pathways without the need for experimental (trial-and-error) optimization. To the best of our knowledge, we were the first to demonstrate the benefits of the MEGA semi-LASER sequence for J-difference editing of the antioxidant glutathione (GSH) in the human brain at 7T. Taken together, the experimental and methodological work of my laboratory set the stage for high-level metabolic studies in clinical populations.

a. Landheer, K., Gajdosik, M, **Juchem, C.** (2020). A semi-LASER, single-voxel spectroscopic sequence with a minimal echo time of 20.1 ms in the human brain at 3 T, *NMR Biomed.* 33:e4324. PMID: 32557880
b. **Juchem, C.**, Cudalbu, C., de Graaf, R.A., Gruetter, R., Henning, A., Hetherington, H.P., Boer, V.O. (2020). B0 shimming for in vivo magnetic resonance spectroscopy: Experts' consensus recommendations. *NMR Biomed.* 34:e4350. PMID: 32596978
c. Landheer, K., **Juchem, C.** (2019). Dephasing optimization through coherence order pathway selection (DOTCOPS) for improved crusher schemes in MR spectroscopy, *Magn. Reson. Med.* 81:2209-2222. PMID: 30390346
d. Prinsen, H., de Graaf, R.A., Mason, G.F., Pelletier, D., **Juchem, C.** (2017). Towards Pathoneurochemical profiling of multiple sclerosis: Single-session measurement of glutathione, GABA and glutamate with MR spectroscopy at 7 Tesla, *J Magn. Reson. Imaging* 45:187-198. PMCID: PMC5167659
e. **Juchem, C.**, Logothetis, N.K., Pfeuffer, J. (2007). 1H-MRS of the macaque monkey primary visual cortex at 7T: Strategies and pitfalls of shimming at the brain surface. *Magn Reson Imag*. 26:902-12. PMDI: 17467220

### 2. Dynamic Shimming with Spherical Harmonic Shapes

Inhomogeneous $B_0$ magnetic fields cause spatial distortions and signal dropout in MRI. To date, limited $B_0$ homogeneity is a primary reason why the expected gains of high and ultra-high field MRI have not been fully kept. Researchers at Yale and Stanford demonstrated in the mid 1990's the gains in $B_0$ homogeneity that can be achieved when linear correction fields are tailored to specific slices and applied in a dynamic fashion, so-called dynamic shimming (as opposed to static shimming that considers the entire region-of-interest at once). Together with my colleagues, I further pushed the limits of spherical harmonic-based $B_0$ shimming with the first successful implementation of zero through third order dynamic shimming with full eddy-current and offset compensation. I carried out the research under the supervision of my PI at the time Dr. Robin A. de Graaf based on amplifier technology developed by Terence W. Nixon. Even today – 10 years later – the achieved $B_0$ homogeneity represents the gold standard for conventional $B_0$ shimming in the human brain.

a. **Juchem, C.**, Nixon, T.W., Diduch, P., McIntyre, S., Rothman, D.L., Starewicz, P., & de Graaf, R.A. (2010). Dynamic shimming of the human brain at 7 Tesla, *Conc. Magn. Reson.* 37B:116-128. PMCID: PMC2907895

b. Boer, V.O., Klomp, D.W.J., **Juchem, C.**, Luijten, P.R., de Graaf, R.A. (2011) Multi-slice $^{1}$H MRSI of the human brain at 7 Tesla using dynamic $B_0$ and $B_1$ shimming. *Magn. Reson. Med.* 68:662-670. PMCID: PMC3306521

**3. Multi-Coil $B_0$ Magnetic Field Control for $B_0$ Shimming and MR Imaging**

For more than half a century $B_0$ magnetic correction fields were generated by dedicated, electrical coils resembling the shapes of low-order spherical harmonic terms. Although this approach does not allow fully satisfactory $B_0$ homogeneity in the rodent or human brain, the exclusive use of these shapes has never been questioned. I took the lead in initiating a complete paradigm shift and, together with my colleagues, developed a new and generalized method that allows the synthesis of advanced magnetic field distributions with generic (i.e. non-orthogonal) basis fields from a set of localized coils. Multi-coil $B_0$ shimming provides dramatically better $B_0$ homogeneity in the mouse, rat and human brain than standard methods and in the future should close to completely eliminate $B_0$ inhomogeneity as a problem.

a. **Juchem, C.**, Theilenberg, S., Kumaragamage, C., Mullen, M., DelaBarre, L., Adriany, G., Brown, P. B., McIntyre, S., Nixon, T. W., Garwood, M., de Graaf, R.A. (2020). Dynamic multicoil technique (DYNAMITE) MRI on human brain. *Magn. Reson. Med.* 84:2953-2963. PMID: 32544274 (*Editor's Pick*)

b. Rudrapatna, U., Fluerenbrock, F., Nixon, T.W., de Graaf, R.A., **Juchem, C.** (2018). Combined imaging and shimming with the dynamic multi-coil technique. *Magn. Reson. Med.* 81:1424-1433. PMCID: PMC4120278

c. **Juchem, C.***, Rudrapatna U.*, Nixon, T.W., de Graaf, R.A. (2015). Dynamic Multi-Coil Technique (DYNAMITE) Shimming for Echo-Planar Imaging of the Human Brain at 7 Tesla. *NeuroImage.* 105:462-472*.* PMCID: PMC4262558

d. **Juchem, C.**, Nixon, T.W., McIntyre, S., Rothman, D.L., & de Graaf, R.A. (2010). Magnetic field modeling with a set of individual localized coils, *J. Magn. Reson.* 204:281-289. PMCID: PMC2884296

**4. Dissemination of Freeware Software Packages**

To date, advanced solutions for optimized experiment preparation, analysis and quantification of MR spectroscopy are limited. Such methods are at the heart of my research program and I share MR sequences, algorithms and processing software with the MR community free of charge. I expect easy access to advanced methods to further promote both research and clinical potential of MR.

a. Landheer K, **Juchem C**. Constrained Optimized Water Suppression (COWS). CTV license: CU21111 (2021). innovation.columbia.edu/technologies/CU21111_COWS

b. Gajdošik M, Landheer K, **Juchem C**. Pocket MRS: Mobile application for rapid analysis of magnetic resonance spectroscopy. CTV license: CU21108 (2021). innovation.columbia.edu/technologies/CU21108_PocketMRS

c. Landheer K, **Juchem C**. Magnetic Resonance Spectrum Simulator (MARSS). CTV license: CU19205 (2019). innovation.columbia.edu/technologies/CU19215_MARSS

d. Landheer K, **Juchem C**. Dephasing optimization through coherence order pathway selection (DOTCOPS) for improved crusher and phase cycling schemes in MR spectroscopy. CTV license CU18146 (2018). innovation.columbia.edu/technologies/CU18406

e. **Juchem C**. INSPECTOR - Magnetic resonance spectroscopy software for *in vivo* biomedical and clinical research. CTV license CU17130 (2017). innovation.columbia.edu/technologies/cu17130_INSPECTOR

f. **Juchem, C**. B0DETOX: $B_0$ detoxification software for magnetic field shimming. CTV license CU17326 (2017), innovation.columbia.edu/technologies/CU17326_B0DETOX

**Complete List of Published Work in PubMed:**
https://www.ncbi.nlm.nih.gov/pubmed/?term=Christoph+Juchem

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**D. Research Support**

**Ongoing Research Support**

R01 EB030560 (Juchem, C) 04/07/2021 – 12/31/2024
NIH / NIBIB
Dynamic Multi-Coil $B_0$ Shimming for Diagnostic MRI of Frontal Brain
In this NIH-R01 project, we combine DYNAMITE $B_0$ shim with clinical RF technology to establish the first integrated multi-coil $B_0$ and radio-frequency (MC/RF) setup dedicated to clinical diagnostics and workflow. The research is significant because it is expected to fundamentally leverage the diagnostic potential of gradient-echo MRI in the ventral PFC and orbits, setting the stage for widespread clinical use of state-of-the-art $B_0$ shim technology and true translation from bench to bedside.
Role: Principal Investigator

R01 MH123142 (Kantrowitz, J, Javitt, D, Grinband, J) 12/01/2020 – 11/30/2025
NIH / NIMH
Glutamatergic mechanisms of psychosis and target engagement
Several glutamate-targeted medications have failed in pivotal clinical trials despite robust effectiveness in preclinical models. The present project further develops ketamine biomarkers for glutamate-based treatments and explores glutamate and dopamine mechanisms of schizophrenia using brain imaging.
Role: Investigator

Established Investigator Grant (Juchem, C) 01/01/2019 – 12/31/2021
General Electric, GE Healthcare
A Fastmap Shim Tool (FAMASITO) for User-Friendly B0 Field Homogenization
This research seeks to integrate advanced B0 magnetic field shimming methodology with GE's EPIC scanner environment for clinical single-voxel MR spectroscopy applications.
Role: Principal Investigator

DOD W81XWH1810221 (Martinez, D) 12/01/2017 – 11/30/2021
Department of Defense (DoD)
Investigation of the NMDA Antagonist Ketamine as a Treatment for Tinnitus
Tinnitus is a very common problem that often accompanies hearing loss. Research in humans and animals suggest that the neurotransmitters glutamate and GABA are important in the development and maintenance of tinnitus. In this project, we will test the effect of ketamine on tinnitus using a placebo controlled design. Magnetic Resonance Spectroscopy (MRS) scans will be obtained at the time of placebo/ketamine infusions to investigate the effect on GABA and glutamate levels.
Role: Investigator

Collaboratory Award (Juchem, C, Kegeles, L) 09/01/2017 – 09/30/2022
Columbia University
In Vivo Magnetic Resonance Spectroscopy - from Data to Clinical Benefit
In this project, we will establish an educational course that comprises all aspects of *in vivo* MRS from theory to experiment, from data acquisition to the derivation of metabolic signatures, and from study design to clinical interpretation. The course will provide an understanding of MRS techniques and bridge the gap between theoretical concepts, hands-on training and direct experimental experience on a human 3T MR scanner.
Role: Co-PI

U01 EB025153 (Garwood, M, University of Minnesota) 09/01/2017 – 08/31/2022
NIH / NIBIB
Imaging Human Brain Function with Minimal Mobility Restrictions
The goal of this project is to build the first-ever human MRI scanner requiring only the head to be inside the magnet bore and having a large window for viewing outside the magnet bore. The small size, weight, and power requirements of this 1.5 Tesla MRI system will enable it to be transported and sited almost anywhere in the world and to bring the magnet to the subject rather than the other way around.
Role: Co-PI of Columbia subcontract