WAKE FOREST SCHOOL OF MEDICINE

Curriculum Vitae

NAME: Christopher Thomas Whitlow, MD, PhD, MHA

CURRENT ACADEMIC TITLE:
Associate Professor, Radiologic Sciences
Associate Professor, Biomedical Engineering
Associate Professor, Translational Science Institute

ADDRESS:
Division of Radiologic Sciences
Department of Radiology
Section of Neuroradiology
Wake Forest School of Medicine
Medical Center Boulevard
Winston-Salem, NC 27157-1088
(336)716-7849 (office)
cwhitlow@wakehealth.edu

EDUCATION:

1997 East Carolina University
Greensville, North Carolina
Bachelor of Arts in Psychology

2004 Wake Forest School of Medicine
Winston-Salem, North Carolina
Doctor of Medicine and Doctor of Philosophy

2014 University of North Carolina at Chapel Hill
Chapel Hill, North Carolina
Master of Healthcare Administration

POSTDOCTORAL TRAINING:

2004-2005 Intern, Internal Medicine
Moses Cone Memorial Hospital
Greensboro, North Carolina

2005-2009 Resident, Diagnostic Radiology
Wake Forest School of Medicine
Winston-Salem, North Carolina

2009-2011 Fellow, Neuroradiology
Wake Forest School of Medicine
Winston-Salem, North Carolina

2012-2014 Executive Masters of Healthcare Administration (MHA) Program
Gillings School of Global Public Health
University of North Carolina at Chapel Hill
Chapel Hill, North Carolina

PROFESSIONAL LICENSURE:

2010-Present	State of North Carolina, #2010-00483

SPECIALTY CERTIFICATION:

2009-Present	American Board of Radiology, #59111

EMPLOYMENT:

7/2010-6/2014	Assistant Professor, Radiologic Sciences
7/2011-6/2014	Assistant Professor, Translational Science Institute
7/2014-Present	Associate Professor, Radiologic Sciences
7/2014-Present	Associate Professor, Translational Science Institute
7/2014-Present	Associate Professor, Biomedical Engineering

OTHER PROFESSIONAL APPOINTMENTS AND INSTITUTIONAL SERVICE:

Academic Appointments:

Wake Forest School of Medicine:

8/2010-5/2012	Associate Director, Combined M.D./Ph.D. Program
5/2012-Present	Director, Combined M.D./Ph.D. Program
5/2012-Present	Course Director, Community Care Clinic Elective
6/2013-Present	House Mentor, Medical Student Learning Community
6/2013-Present	Course Director, Radiology Research Elective
1/2014-Present	Faculty, School of Medicine LAUNCH Program
3/2014-Present	Clinical Coach, Medical Student Clinical Skills Curriculum

Karolinska Institutet:

1/2014-Present	Honorary Research Fellow, Department of Women's and Children's Health, Institute for Neonatology, Stockholm, Sweden http://ki.se/en/people/chrwhi

Hospital, School, Medical Center Committees and Service:

2010-Present	M.D./Ph.D. Program Curriculum Committee Wake Forest School of Medicine
2010-Present	Radiology Resident Education Committee Wake Forest School of Medicine
2010-Present	Neuroradiology Fellowship Selection Committee Wake Forest School of Medicine
2012-Present	Community Care Clinic Elective Committee Wake Forest School of Medicine
2013-Present	Medical Student Learning Community House Mentorship Committee Wake Forest School of Medicine
2013-Present	Biomedical Sciences Committee Wake Forest School of Medicine

2013-Present	Quality Improvement Medical School Curriculum Committee Wake Forest School of Medicine
2014-Present	Committee on Graduate School of Arts and Sciences Wake Forest School of Medicine
2014-Present	Neuroscience Graduate Program Executive Committee Wake Forest School of Medicine
Nominated	Student Professionalism and Academic Review Committee Wake Forest School of Medicine

National Committee Appointments and Service:

2008-Present	Neuroradiology Educational Exhibit Review Panel Radiological Society of North America (RSNA)
2011-present	Research Committee American Society of Functional Neuroradiology (ASFNR)
2012-present	Research Committee American Society of Neuroradiology (ASNR)
2012-present	Neuroradiology/Head & Neck Scientific Program Committee Radiological Society of North America (RSNA)
2012-present	New Investigators Committee Coronary Artery Risk Development in Young Adults (CARDIA) National Heart, Lung, and Blood Institute (NHLBI)
2012-present	Brain Magnetic Resonance Imaging Data Analysis Working Group Coronary Artery Risk Development in Young Adults (CARDIA) National Heart, Lung, and Blood Institute (NHLBI)
2013-present	MD-PhD Section Committee Group on Graduate Research Education and Training (GREAT) of the American Association of Medical Colleges (AAMC)
2013-present	Co-Chair, Study Group for Clinical Translation of Functional & Diffusion MRI American Society of Neuroradiology (ASNR)
2013-present	Head Imaging-Reporting and Data System (HI-RADS) Committee American College of Radiology (ACR) Head Injury Institute
2013-present	Research Committee American College of Radiology (ACR) Head Injury Institute
2014-present	Program Committee American Society of Neuroradiology (ASNR)
2014-present	Clinical Councilor Western North Carolina Chapter of Society for Neuroscience

2014-present	Public Information Advisors Network (PIAN) Radiological Society of North America (RSNA)

Service at National/International Meetings:

2011	Presiding Officer - Scientific Paper Session "Cognition" Radiologic Society of North America 2011 Annual Meeting
2013	Presiding Officer - Scientific Paper Session "Resting State Functional Brain Imaging" Radiologic Society of North America 2013 Annual Meeting
2014	Presiding Officer - Scientific Paper Session "Stroke and Cerebrovascular Reserve" Radiologic Society of North America 2014 Annual Meeting
2014	Presiding Officer - Scientific Paper Session "Resting State Functional Brain Imaging" Radiologic Society of North America 2014 Annual Meeting
2015	Moderator - Scientific Paper Session "Machine Learning" American Society of Functional Neuroradiology 2015 Annual Meeting
2015	Moderator - Symposium "Omics & Big Data for Brain Development / Neurodegenerative Disorders" American Society of Neuroradiology 2015 Annual Meeting

Journal Editorial Boards: *British Medical Journal Case Reports*

Journal Reviewer:
American Journal of Neuroradiology (AJNR)
Brain Research Bulletin
British Medical Journal Case Reports
Cerebral Cortex
Journal of Clinical and Experimental Neuropsychology
Journal of Neurotrauma
NeuroImage
Neuroradiology
New England Journal of Medicine
Psychopharmacology
RadioGraphics
Radiology

Funding Agency Reviewer: The Foundation of the American Society of Neuroradiology Grant Review Panel (2013)

PROFESSIONAL MEMBERSHIPS:

2004-present	Alpha Omega Alpha Honor Medical Society Member
2015-present	American College of Radiology Member
2012-present	American Medical Association Member
2005-present	American Society of Neuroradiology Member
2007-present	American Society of Functional Neuroradiology Member
2000-present	International Society of Cerebral Blood Flow and Metabolism Member
2004-present	Radiological Society of North America Member
1998-present	Society for Neuroscience Member

HONORS AND AWARDS:

1994	University Book Exchange Scholarship
1997	Magna cum laude with honors in Psychology
1998	M.D./Ph.D. Academic Scholarship
1998-2004	National Institutes of Health NRSA M.D./Ph.D. Predoctoral Fellowship Grant
1999	WFU School of Medicine Medical Student Research Day Poster Award: *Persistent effects of the acute administration of Δ^9-tetrahydrocannabinol on rates of local cerebral glucose utilization in the rat.*
2000-2002	President, Student Interest Group in Neurology
2001	National Institute on Drug Abuse Travel Award: ICRS Annual Meeting
2003	Alpha Omega Alpha Honor Medical Society
2004	Published Art: Mantle. Oil glaze on canvas. JAMA. 2004; 2291: 1639-1640
2004	Richard L. Burt Research Achievement Award
2004	I. Meschan Radiology Merit Award
2004	Medical Student Prize for Excellence in Neurology, American Academy of Neurology
2006	Introduction to Research Program, Radiological Society of North America
2007	Presidents Circle Research & Education Foundation Research Resident

	Grant, Radiological Society of North America
2007	Editorial Fellowship for Trainees, Radiological Society of North America
2008	American Society of Functional Neuroradiology Poster Award: *Time-dependent changes in cerebral perfusion associated with posterior reversible encephalopathy: A magnetic resonance arterial spin labeling investigation.*
2008	Roentgen Resident Research Award, Radiological Society of North America Research & Education Foundation
2008	Derek Harwood Nash Awards in Pediatric Neuroradiology Research, American Society of Neuroradiology and American Society of Pediatric Neuroradiology
2009	American Society of Neuroradiology (ASNR) Bayer/Neuroradiology Education & Research Foundation Fellowship in Basic Science Research
2009	Elias G. Theros, M.D. Research Award, Dept. of Radiology, Wake Forest School of Medicine
2009	Radiological Society of North America Trainee Research Prize: *Effect of constant angle insonation versus varied angle insonation on measurement of Doppler velocities in a model of carotid artery stenosis.*
2010	Roentgen Fellow Research Award, Radiological Society of North America Research & Education Foundation
2011	American Society of Functional Neuroradiology Poster Award: *Effect of Resting-state fMRI repetition time on accuracy of computed graph theory metrics of brain network connectivity.*
2014	*RadioGraphics*, Editor's Recognition Award for reviewing with distinction

INVITED PRESENTATIONS AND SEMINARS:

1. **Whitlow CT**, Freedland CS, Miller MD, Porrino LJ. Chronic effects of Δ^9-tetrahydrocannabinol on rates of local cerebral glucose utilization in rats. International Cannabinoid Research Society, 11th Annual Symposium on the Cannabinoids, 2001, San Lorenzo de El Escorial, Spain.

2. **Whitlow CT**, Freedland CS, Porrino LJ. Functional consequences of the repeated administration of Δ^9-tetrahydrocannabinol. Society for Neuroscience 31st Annual Meeting, 2001, San Diego, California.

3. **Whitlow CT**, Reedy ML, Cotton JR, Kaminsky SE, Berry JL, Morris PP. Investigating sacroplasty: Technical considerations and biomechanical properties of sacral polymethylmethacrylate infusions in cadaveric pelvic specimens. Radiological Society of North America's 90th Scientific Assembly and Annual Meeting, 2004, Chicago, Illinois.

4. **Whitlow CT**, Eberhardt AW, Yazdani SK, Reedy ML, Berry JL, Morris PP. Fluoroscopy-guided percutaneous injection of polymethylmethacrylate into cadaveric hip: A possible prophylactic treatment for individuals at risk for hip fracture. Radiological Society of North America's 91st Scientific Assembly and Annual Meeting, 2005, Chicago, Illinois.

5. **Whitlow CT**, Pollock JM, Mussat-Whitlow BJ, Kraft RA, Tan H, Burdette JH, Maldjian JA. Changes in Global

Rates of Cerebral Perfusion Associated with Normal Development as Measured with MR Arterial Spin Labeling. American Society of Neuroradiology 46th Annual Meeting, 2008, New Orleans, Louisiana.

6. **Whitlow CT**, Pollock JM, Mussat-Whitlow BJ, Kraft RA, Tan H, Burdette JH, Maldjian JA. Age-Related Changes in Global Rates of Cerebral Perfusion From Birth to Age 92: A Magnetic Resonance Arterial Spin Labeling Investigation. Radiological Society of North America's 94th Scientific Assembly and Annual Meeting, 2008, Chicago, Illinois.

7. **Whitlow CT.** Age-Related Changes in Global Rates of Cerebral Perfusion From Birth to Age 92: A Magnetic Resonance Arterial Spin Labeling Investigation. Radiology Resident Conference Wake Forest School of Medicine, 2009, Winston-Salem, NC.

8. **Whitlow CT**, Pollock JM, Tan H, Kraft RA, Burdette JH, Maldjian JA. Pulsed Arterial Spin-Labeled MR Imaging Evaluation of Tuberous Sclerosis. American Society of Neuroradiology 47th Annual Meeting, 2009, Vancouver, British Columbia, Canada.

9. **Whitlow CT**, Tchelepi HA, Grant EG, Matcuk GR. Effect of Constant Angle Insonation Versus Varied Angle Insonation on Measurement of Doppler Velocities. Radiological Society of North America's 95th Scientific Assembly and Annual Meeting, 2009, Chicago, Illinois.

10. **Whitlow CT.** Age-related changes in global rates of cerebral perfusion in normal children, adolescents, and young adults: A magnetic resonance arterial spin labeling investigation. Radiology Resident Conference Wake Forest School of Medicine, 2010, Winston-Salem, NC.

11. **Whitlow CT**, Maldjian JA. Effect of resting-state fMRI BOLD acquisition duration on accuracy of computed graph theory metrics of brain network connectivity. American Society of Functional Neuroradiology 5th Annual Meeting, 2011, Phoenix, Arizona.

12. **Whitlow CT**. It's a small world after all: The application of graph theoretical analysis to the study of brain network connectivity. American Society of Neuroradiology 49th Annual Meeting, 2011, Seattle, Washington.

13. **Whitlow CT**, Maldjian JA. Pulsed arterial spin labeling time-series data can be used to accurately compute graph theory metrics of global distributed brain connectivity. American Society of Neuroradiology 49th Annual Meeting, 2011, Seattle, Washington.

14. **Whitlow CT**. Fundamentals of experimental design, performance, and interpretation of results – Part I. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2011, Winston-Salem, NC.

15. **Whitlow CT**. Fundamentals of experimental design, performance, and interpretation of results – Part II. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2011, Winston-Salem, NC.

16. **Whitlow CT**. Opportunities for Graduate Education. Summer Undergraduate Research Program Wake Forest School of Medicine, 2011, Winston-Salem, NC.

17. **Whitlow CT**, Chan MD, Wagner JS, Sauer RN, Lesser GJ, Bennett M, Tatter SB, Ellis TL, Paulsson AK, Johnson AJ. Glioblastoma multiforme progression or treatment-related pseudoprogression? A direct comparison of common MRI diffusion and perfusion sequences at the neuroradiology clinical workstation. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

18. **Whitlow CT**, Maldjian JA. Combining graph theoretical analysis and conventional anatomical MRI: A new voxel-wise approach for constructing disease-specific structural brain networks applied to Alzheimer's disease. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

19. **Whitlow CT**. Characterizing novel MRI features of brain tumors for use as imaging biomarkers of histology. Brain Tumor Center of Excellence 9th Annual Retreat September 7, 2012, Winston-Salem, NC.

20. **Whitlow CT**. Fundamentals of experimental design, performance, and interpretation of results – Part I. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2012, Winston-Salem, NC.

21. **Whitlow CT**. Fundamentals of experimental design, performance, and interpretation of results – Part II. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2012, Winston-Salem, NC.

22. **Whitlow CT**. Opportunities for Graduate Education. Summer Undergraduate Research Program Wake Forest School of Medicine, 2012, Winston-Salem, NC.

23. **Whitlow CT**. Utility of Common MRI Diffusion and Perfusion Sequences for Discriminating Glioblastoma Multiforme Progression from Pseudoprogression at the Clinical PACS Workstation. Brain Tumor Center of Excellence, 2013, Winston-Salem, NC.

24. **Whitlow CT.** Advanced Resting State Analysis and Research Applications: PCA, ICA, Graph Theory. American Society of Functional Neuroradiology 7th Annual Meeting, 2013, Charleston, South Carolina.

25. **Whitlow CT.** Evolving Patterns of Connectivity in the Developing Brain: A Magnetic Resonance Imaging Computational Network Investigation. Department of Obstetrics and Gynecology, Jim Rose Laboratory Seminar, 2013, Winston-Salem, NC.

26. **Whitlow CT,** Brashear A. Structural Abnormalities of the Brain in Patients with ATP1A3 Gene Mutations and Rapid-Onset Dystonia-Parkinsonism. Neuroradiology Grand Rounds, 2013, Winston-Salem, NC.

27. **Whitlow CT.** An informative session about the professions: Neuroscience and language. Wake Forest University Undergraduate Seminar, 2013, Winston-Salem, NC.

28. **Whitlow CT**. Opportunities for Postgraduate Education. Summer Undergraduate Research Program Wake Forest School of Medicine, 2013, Winston-Salem, NC.

29. **Whitlow CT.** Fundamentals of experimental design, performance, and interpretation of results – Part I. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2013, Winston-Salem, NC.

30. **Whitlow CT.** Fundamentals of experimental design, performance, and interpretation of results – Part II. Radiology Resident and Neuroradiology Fellow Conference Wake Forest School of Medicine, 2013, Winston-Salem, NC.

31. **Whitlow CT.** Evolving patterns of connectivity in the neonatal brain: A magnetic resonance imaging computational network investigation. Radiology Resident Conference, Wake Forest School of Medicine, 2013, Winston-Salem, NC.

32. **Whitlow CT.** Bias in Medicine. Medical Student Small Group Discussion, Wake Forest School of Medicine,

2013, Winston-Salem, NC.

33. **Whitlow CT.** Advanced Resting State Analysis and Research Applications: PCA, ICA, Graph Theory. American Society of Functional Neuroradiology 8th Annual Meeting, 2014, Miami, Florida.

34. **Whitlow CT.** Imaging the neonatal brain: Advanced MRI methods and analysis techniques. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

35. **Whitlow CT.** Patterns of Structural Co-Variance Associated with Autism Spectrum Disorder in Extremely Preterm Neonates: A Novel Voxel-Wise Graph Theoretic Approach. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

36. **Whitlow CT**, Druzgal JT. Translational Imaging. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

37. **Whitlow CT**. Introduction to the ASNR Study Group for the Clinical Translation of Functional and Diffusion MRI. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

38. **Whitlow CT.** Plenary Session: From population-based to patient-based TBI imaging interpretation: Setting the stage, defining the problem and drawing a roadmap towards an ultimate goal. Joint ASNR-ACR HII-ASFNR TBI Workshop: Bringing Advanced Neuroimaging for TBI into the Clinic. 2014, Montreal, Quebec, Canada.

39. **Whitlow CT**. Opportunities for Postgraduate Education. Summer Undergraduate Research Program Wake Forest School of Medicine, 2014, Winston-Salem, NC.

40. **Whitlow CT.** Introduction to Radiology. Medical Student Lecture, Wake Forest School of Medicine, 2014, Winston-Salem, NC.

41. **Whitlow CT.** Clinical Perspectives in fMRI: Current state of neuroradiologic applications for patient care. International Society for Magnetic Resonance in Medicine Scientific Workshop. Functional MRI: Emerging Techniques & New Interpretations, 2014, Charleston, SC.

42. **Whitlow CT.** PCA, ICA, Graph Theory. American Society of Functional Neuroradiology 9th Annual Meeting, 2014, Tucson, AZ.

43. **Whitlow CT.** Dynamic Resting State. American Society of Functional Neuroradiology 9th Annual Meeting, 2014, Tucson, AZ.

44. **Whitlow CT.** Normative Databases and Machine Learning: Does it Matter for Neuroradiology? American Society of Neuroradiology 53nd Annual Meeting. Omics and Big Data for Neuroradiology Minisymposium,2015, Chicago, IL.

45. **Whitlow CT.** Managing Big Data from MRI: the Neuroradiologist's Perspective. International Society for Magnetic Resonance in Medicine 23rd Annual Meeting. Genomics, Proteomics, & Big Data Course. 2015, Toronto, ON, Canada.

46. **Whitlow CT.** Patterns of structural co-variance associated with autism spectrum disorder in extremely preterm neonates: A novel voxel-wise graph theoretic approach. 2015 Visiting Professor, Karolinska Institutet, Stockholm, Sweden.

GRANTS:

CURRENT

1. R01 NS075107 PI: Freedman/Maldjian/Divers 06/2011-07/2016

Cerebrovascular Disease and Cognitive Performance in African Americans.

This project will evaluate cerebrovascular disease (CBVD) in African Americans (AA) with type 2 diabetes, and compare results to existing MRI and cognitive data in a cohort of European Americans with type 2 diabetes. The goal is to determine whether racial differences exist in the relationship between CBVD and cognitive performance and to identify the environmental and inherited causes of CBVD in the high risk and understudied AA population.

Role: Co-Investigator

2. Childress Institute for Pediatric Trauma PI: Stitzel/Maldjian/ Powers 06/2012-Present

The Kinematics of Impact Data Set (KIDS).

This project is being conducted through the Virginia Tech – Wake Forest University School of Biomedical Engineering and Sciences (SBES). Over 240 football helmets will be instrumented to map mechanical forces of head impact exposure on six different youth football teams in Virginia and North Carolina (age range 6 to 18 years). Structural and functional brain imaging will be acquired from a subset of teams before and after the season, as well as after concussion to identify changes in the brain associated with head impacts. It is anticipated that this research program will greatly enhance the understanding of child brain biomechanics.

Role: Co-Investigator

3. U01 NS077953 PI: Juul 06/2013-05/2018

PRETERM EPO NEUROPROTECTION (PENUT) TRIAL.

Infants born before 28 weeks of gestation, termed Extremely Low Gestational Age Neonates (ELGANs), experience high morbidity and mortality. New approaches are needed to improve these outcomes. Recombinant erythropoietin (Epo) is a promising novel neuroprotective agent. We hypothesize that Epo treatment of ELGANs will confer improved neurodevelopmental outcome at 24-26 months PMA compared to placebo, and will provide a much-needed therapy for this group of vulnerable infants. Furthermore, we anticipate that Epo treatment will be safe, will decrease biomarkers of brain injury and inflammation, and will be associated with less preterm brain injury as determined by MRI at 36 weeks PMA.

Role: Neuroradiologist/Neuroimaging Consultant

4. Alzheimer's Disease Association PI: Baker 06/2013-05/2014

Piedmont Aging, Cognition, & Exercise Study-2 (PACE-2).

The aim of this study is to evaluate the effects of aerobic exercise on cognition and disease related biomarkers for a group of older adults with mild cognitive impairment and pre-diabetes. Exercise offers a unique intervention strategy with salutary target effects on multiple biological systems that succumb to age and disease-related deterioration and as a consequence, stands to make a significant contribution to the maintenance of the brain health for adults with MCI. The imaging data collected will provide important information about potential mechanisms that support beneficial effects of aerobic exercise on cognition in this population of adults.

Role: Neuroradiologist/Neuroimaging Co-Investigator

5. NIA R37 PI: Craft 06/2013-05/2014

Glucose Regulation and Memory in Alzheimer's Disease.

The proposed studies will test the hypothesis that diet modulates cognitive and biologic markers of Alzheimer's disease, and that a specific form of insulin-resistance, characterized by hypertension, is associated with abnormal patterns of these markers in midlife. Identification of a clear metabolic risk profile in middle age may offer an opportunity for preventative strategies. The proposed study

will address one such strategy; consumption of a low saturated fat/low glycemic index diet. Endpoints will be cognition, CSF and plasma Ap levels, lipoprotein/lipid levels, and cerebral blood flow (arterial spin labeling perfusion MRI).
Role: Neuroradiologist/Neuroimaging Co-Investigator

6. DARPA-14-08-RAM-FP-003 PI: Deadwyler 02/2014-06/2015

RAM: Restoring Active Memory

Development of a computational model of neurobiological mechanisms underlying memory in humans. Restoration of multiple types of complex memories in human and animal models.
Role: Co-Investigator

7. R01 NS082453 PI: Maldjian/Stitzel 07/2014-06/2019

iTAKL: Imaging Telemetry And Kinematic modeLing in Youth Football

This study will relate information about head motion during impact in youth football leagues (8-12 years old) to neurocognitive and imaging data to determine the effects of subconcussive mechanical force, and the true incidence of cognitive and objective imaging changes. The overall aim of this investigation is to increase our understanding of pediatric mild traumatic brain injury (mTBI) by prospectively collecting and analyzing biomechanical, neuroimaging, neurocognitive and computational modeling data on a scale never before attempted.
Role: Co-Investigator

8. RO1 (NINDS) PI: Brashear 07/2015-06/2020

Clinical, Genetic, And Cellular Consequences of Mutations in Na,K-ATPase ATP1A3

This project addresses a fundamental question in neuroscience. How do mutations in ATP1A3 affect neural networks in the brain and cause a spectrum of disease in children and adults? The current barriers are first, recognition/diagnosis of the rare diseases caused by ATP1A3 mutation, and second, treatment of patients with devastating and irreversible neurologic deficits. Based upon our work in funding cycle (FC1) and given the increasing number of de novo mutations, ATP1A3 mutations are likely under-reported. This gives us an opportunity to define an intermediate phenotype between AHC and RDP.
Role: Co-Investigator

Pilot Projects

1. Pilot Study of R01 NS075107 PI: **Whitlow** 07/2012-07/2018

Cellular Microparticles: Blood-Borne Biomarker of Vascular Pathology in Diabetes.

The goal of this study is to develop a blood-borne biomarker of diabetes-induced vascular pathology based on a cellular microparticle (MP) marker of angiogenesis. MPs are small blood-borne cell fragments shed from the surface of blood cells and vascular endothelial cells after activation. MPs can be obtained by venous blood draw, extracted by centrifugation, labeled by fluorescent markers, and examined by flow cytometry. The angiogenesis MP marker is a specific isoform of aminopeptidase N not found on normal endothelial cells. This marker is being used in clinical trials to deliver drugs to angiogenic blood vessels in tumors. The primary aim of our study will be to demonstrate early stage proof-of-concept, formulation of reagents, optimization of procedures, and clinical interpretation of the biomarker. Specifically, we will develop fluorescently-tagged peptide reagents to stain MPs. This biomarker can be used to survey for vascular disease that involves reactive angiogenesis.
Role: Principal Investigator

2. WFUHS Intramural Pilot Funding PI: **Whitlow** 11/2013-11/2015

Acquisition of normal control data for use in preliminary studies of sports-related mild TBI

The purpose of this project is to acquire neuroimaging (MRI and MEG) and neurocognitive data from a cohort of youth and high school athletes who are not exposed to repetitive head impacts during their sports season (e.g., swimmers). Data from this control group will be compared to a similar already acquired dataset from youth and high school football players, allowing preliminary risk assessment of cumulative head impact exposure on cognitive function, as well as brain structure and function. By evaluating young athletes with a range of cumulative head impact exposure (from none to high) we will be able to better characterize outcomes of concussive and subconcussive head impacts, addressing gaps in knowledge about pediatric TBI that have important public health consequences. These preliminary analyses will form the basis of future larger longitudinal evaluations of cumulative football-related head impact exposure, using similar biomechanical modeling, neuroimaging and neurocognitive assessment.
Role: Principal Investigator

PENDING

1. U01-NIDA PI: **Whitlow/**Maldjian Pending Submission 4/14/2015

Adolescent Brain Cognitive Development (ABCD) Study - Research Project Site

Adolescence is characterized by marked changes in brain structure and function that may increase the vulnerability to the effects and risks of substance use. Cumulative non-concussive sports-related head impact exposure has also been shown to affect brain areas that mediate sensation seeking, impulsivity, and risk-taking behaviors that may exacerbate the vulnerability to substance use and addiction. The aim of this longitudinal study is to follow a cohort of youth athletes (9-10 years old; n=600) through adolescence to determine if head-impact exposure related changes in the trajectory of brain development contributes to the increased use of alcohol, tobacco, marijuana, and other substances.
Role: Principal Investigator

2. R01-NINDS PI: **Whitlow**/Maldjian/Stitzel Pending Submission 6/5/2015

iTAKL: Imaging Telemetry And Kinematic modeLing in high school football

Football head injuries involve significant forces and can result in mild to severe traumatic brain injuries. While this has received increasing attention at the professional and collegiate levels, there is less data available for the millions of participants in high school leagues (14-18 years old) during this time of rapid brain development. The purpose of this study is to relate information about cumulative head impact exposure in high school football to neurocognitive and neuroimaging data to determine the effects of subconcussive impacts, and the true incidence of cognitive and objective imaging changes.
Role: Principal Investigator

3. Dystonia Medical Research Foundation PI: **Whitlow** Under Review

Neural Circuits Associated with Rapid-Onset Dystonia-Parkinsonism and Acute Treatment-Related Effects of Flunarizine

Rapid-onset dystonia-parkinsonism (RDP) is a rare form of dystonia caused by mutations of the *ATP1A3* gene that results in dysfunction of a sodium/potassium ion-transporting ATPase (Na,K-ATPase) expressed in neurons of the brain. In this study, we will use magnetoencephalography to measure the connectivity of brain circuits that we have previously shown with structural MRI to be affected by RDP. We will also determine how the calcium channel blocker, flunarizine, which has shown promise for treating RDP, affects the functions of these brain circuits.
Role: Principal Investigator

4. DARPA PI: Obeid Under Review

Advancing Clinical Neurology Using Hierarchical-Deep Models

Localization of the seizure onset zone (SOZ) prior to epilepsy surgery is critical for minimizing the

volume of brain tissue resected to render the patient seizure-free. Conventional clinical neuroimaging methods fail to localize the SOZ in one-fourth of patients presenting for pre-surgical evaluation. Poor seizure control post-surgery in patients with neuroimaging-negative partial epilepsy is related in part to limitations in the ability to identify the precise location and extent of the SOZ. Application of advanced hierarchical-deep models to neuroimaging feature space and clinical metadata may revolutionize individual patient diagnosis and surgical care for this devastating disease.
Role: Principal Investigator-WFUHS Subcontract

5. RO1 (NIA) PI: Shively Under Review
Paroxetine Effects on Atherosclerosis in Surgically Menopausal Primates
The central hypothesis of this proposal is that paroxetine will alter risk factor profiles and exacerbate atherogenesis. The goal of this research is to determine the risk of atherogenesis associated with the use of paroxetine at doses prescribed for depression (standard dose), and hot flashes (low dose). The approach will utilize a preclinical randomized nonhuman primate trial. The specific aims are to determine the effects of paroxetine on atherosclerosis development and atherosclerosis risk factors, including changes in the brain, as measured with MRI. Additional aims are to determine whether paroxetine has estrogen activity in vivo, and whether the effects of depression on atherosclerosis are modified by paroxetine.
Role: Co-Investigator

6. P50 (NIDA) PI: Porrino, Childers Under Review
Center for the Neurobiology of Addiction Treatment (CNAT)
CNAT is a collaborative multi-disciplinary research and educational program designed to explore the neurobiology of drug abuse. The scientific theme of the Center is focused on examining the neurobiological mechanisms of action of drugs that are currently used, or proposed to use, in the clinic for treatment of cocaine addiction. The proposed projects will utilize several animal models and technologies (including neuroimaging) developed by the Center investigators over the previous years of its funding history. CNAT is unique in its capability of performing integrated research on drug abuse in parallel models of addiction in both rodents and non-human primates.
Role: Co-Investigator

7. P30 (NIDA) PI: Maldjian Under Review
Translational Neuroimaging Analysis Center
This proposal will establish a NIDA Core Center of Excellence providing advanced neuroimaging analysis capabilities for human and non-human primate (NHP) translational studies falling within the NIDA mission, using the most sophisticated algorithms available. These now include sophisticated NHP morphometric and imaging analyses using detailed atlases and software tools developed in his lab. The proposed Center will provide advanced neuroimaging analytic capabilities including MRI, PET and MEG, for human and NHP translational studies for the Wake Forest NIDA-funded research community and to other federally funded projects.
Role: Co-Investigator

PAST GRANT HISTORY:

1. NIH NRSA F30 DA05911 PI: **Whitlow** **100% effort** 07/1998-06/2004
Neuroanatomical Substrates and Cognitive Effects of Cannabinoids: A Translational Neuroimaging Approach.
The purpose of this proposal is to characterize the primary neuroanatomical substrates affected by the cannabinoid agonist, delta 9-tetrahydrocannabinol. A translational neuroimaging model will be used in which initial functional neuroimaging data (2-[^{14}C] deoxyglucose autoradiography) from a

well-controlled laboratory animal model guides subsequent functional magnetic resonance imaging investigations in human subjects with chronic cannabinoid exposure.
Role: Principal Investigator

2. RSNA RR0724 PI: **Whitlow** **50% effort** 07/2007-06/2009
Percutaneous Femoroplasty for Preventing Hip Fracture: Procedural Development and Finite Element Analysis.
The purpose of this proposal is to develop and investigate a new relatively inexpensive minimally invasive image guided procedure for preventing hip fractures due to falls. We hypothesize that augmentation of osteoporotic femoral necks by controlled economic delivery of polymethylmethacrylate bone-cement, termed femoroplasty, will be mechanically effective in reducing stresses in the femoral neck under fall conditions.
Role: Principal Investigator

3. ASNR Research Fellowship PI: **Whitlow** **50% effort** 07/2009-06/2011
Evolving Patterns of Network Connectivity in the Developing Brain: An MRI and Computational Network Analytical Investigation.
The purpose of this study is to identify age-associated temporal changes in brain connectivity during the first 3 years of life that underlies brain maturation by combining MRI and graph theoretical analysis.
Role: Principal Investigator

4. TSI KL2 PI: **Whitlow** **75% effort** 10/2011-12/2013
Identifying Novel Brain Anatomical Biomarkers of Preterm Birth That Predict Future Cognitive Impairment: A Graph Theoretical Network Analysis and Machine Learning Investigation.
The purpose of this study is to identify preterm-birth associated biomarkers predictive of future cognitive impairment using structural MRI combined with machine learning and network connectivity analyses.
Role: Principal Investigator

5. R01 HL098445 PI: Carr **5% effort** 08/2010-04/2014
Longitudinal Changes in Pericardial Adiposity and Subclinical Atherosclerosis
Obesity in early life in African American and white adults is a factor in premature heart disease and cardiovascular death. We will leverage an existing study of 5,115 individuals with 25 years of follow-up to make new measurements with CT and echocardiography. We will determine how changes in the fat located around the heart over ten years in adults 33-55 years influences subsequent heart disease.
Role: Principal Investigator-WFUHS Subcontract

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3. Letchworth SR, Smith HR, Hart SL, Allen JW, **Whitlow CT**, Davies HML, Childers SR, Porrino LJ. The novel cocaine analog, [^{3}H]PTT, as a functional marker of the dopamine transporter. Society for Neuroscience 27th Annual Meeting, 1997, New Orleans, Louisiana.

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37. **Whitlow CT**, Maldjian JA. Characterization of glial cell intratumoral fMRI resting-state networks using graph theoretical analysis. Cancer Imaging and Radiation Therapy Symposium: A Multidisciplinary Approach, 2011, Atlanta, Georgia.

38. **Whitlow CT**, Maldjian JA. Altered functional network connectivity in patients with brain tumors: A resting-state fMRI and graph theory investigation. Cancer Imaging and Radiation Therapy Symposium: A Multidisciplinary Approach, 2011, Atlanta, Georgia.

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50. Soun JE, Pollock JM, Maldjian JA, **Whitlow CT**. Arterial spin labeling perfusion MRI differentiates tumefactive demyelinating lesions from glioblastoma multiforme. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

51. Westcott G, Maldjian JA, **Whitlow CT**. Multimodal biological parametric mapping reveals the effect of gray-matter atrophy on positron emission tomography measures of hypometabolism associated with Alzheimer's disease. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

52. Urban JE, **Whitlow CT**, Maldjian JA, Powers AK, Stitzel JD. Combining clinical neuroimaging and real-world mechanical impact data to investigate motor vehicle crash-related subdural hematoma. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

53. Urban JE, Maldjian JA, **Whitlow CT**, Stitzel JD. Semi-automated landmark identification method used to quantify age-related shape change of brain structures. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

54. **Whitlow CT**, Maldjian JA. Combining graph theoretical analysis and conventional anatomical MRI: A new voxel-wise approach for constructing disease-specific structural brain networks applied to Alzheimer's disease. American Society of Neuroradiology 50th Annual Meeting, 2012, New York, New York.

55. **Whitlow CT**, Chan MD, Wagner JS, Sauer RN, Lesser GJ, Bennett M, Tatter SB, Ellis TL, Paulsson AK, Johnson AJ. Glioblastoma multiforme progression or treatment-related pseudoprogression? A direct comparison of common MRI diffusion and perfusion sequences at the neuroradiology clinical workstation. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

56. Moody EA, **Whitlow CT**, Bowden DW, Maldjian JA. Graph theoretical analysis applied to structural MRI data reveals disease-specific gray-matter changes in patients with diabetes mellitus. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

57. Soun JE, Pollock JM, Maldjian JA, **Whitlow CT**. Arterial spin labeling perfusion MRI differentiates tumefactive demyelinating lesions from glioblastoma multiforme. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

58. Westcott G, Maldjian JA, **Whitlow CT**. Multimodal biological parametric mapping reveals the effect of gray-matter atrophy on positron emission tomography measures of hypometabolism associated with Alzheimer's disease. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

59. Urban JE, **Whitlow CT**, Maldjian JA, Powers AK, Stitzel JD. Combining clinical neuroimaging and real-world

mechanical impact data to investigate motor vehicle crash-related subdural hematoma. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

60. Urban JE, Maldjian JA, **Whitlow CT**, Stitzel JD. Semi-automated landmark identification method used to quantify age-related shape change of brain structures. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

61. **Whitlow CT**, Maldjian JA. Combining graph theoretical analysis and conventional anatomical MRI: A new voxel-wise approach for constructing disease-specific structural brain networks applied to Alzheimer's disease. American Society of Functional Neuroradiology 6th Annual Meeting, 2012, Orlando, Florida.

62. Ghetti B, Hagan MC, Maldjian JA, **Whitlow CT**, Ozelius LJ, Sweadner KJ, Brashear A. Rapid onset dystonia-Parkinsonism associated with the I758S ATP1A3 mutation: A neuropathologic study of three affected siblings. American Neurological Association 137th Annual Meeting, 2012, Boston, MA.

63. **Whitlow CT**, Brashear B, Ghetti B, Hagan MC, Sweadner KJ, Maldjian JA. Structural abnormalities in the brain associated with rapid onset dystonia-Parkinsonism: A preliminary investigation. American Neurological Association 137th Annual Meeting, 2012, Boston, MA.

64. Urban JE, **Whitlow CT**, Maldjian JA, Stitzel JD. Combining Clinical Neuroimaging and Real-World Impact Data to Investigate Motor Vehicle Crash-Related Subarachnoid Hemorrhage. American Society of Mechanical Engineering 2012 Summer Bioengineering Conference, San Juan, PR.

65. **Whitlow CT**, Maldjian JA. Brain intratumoral graph theory network metrics can be computed from resting-state BOLD signal and may vary by tumor histological subtype. 3rd Biennial Resting State Conference. 2012, Magdeburg, Germany.

66. **Whitlow CT**, Maldjian JA. Graph theory network metrics can be accurately computed from clinical task-based fMRI bold signal acquired during routine presurgical motor and language brain mapping in patients with glial cell malignancies. 3rd Biennial Resting State Conference 2012, Magdeburg, Germany.

67. **Whitlow CT**, Jung Y, Maldjian JA. Accurate graph theory metrics of brain network connectivity can be computed across a range of pulse sequence repetition times, including those used for clinical pulsed arterial spin labeling perfusion MRI. 3rd Biennial Resting State Conference 2012, Magdeburg, Germany.

68. **Whitlow CT**. Characterizing novel MRI features of brain tumors for use as imaging biomarkers of histology. Brain Tumor Center of Excellence 9th Annual Retreat September 7, 2012, Winston-Salem, NC.

69. Moody EA, **Whitlow CT**, Maldjian JA. Age-specific gray-matter changes in pediatric subjects is reveled by graph theoretical analysis applied to structural MRI data. Biomedical Engineering Society (BMES) 2012 Annual Meeting, Atlanta, Georgia.

70. Urban J, **Whitlow CT**, Maldjian JA, Powers A, Stitzel J. Volumetric analysis of motor vehicle crash-related brain injuries from real-world head impact data. Biomedical Engineering Society (BMES) 2012 Annual Meeting, 2012, Atlanta, Georgia.

71. Romesburg JW, Geer CP, Lowther EL, **Whitlow CT**. Is CTA clinically useful in the evaluation of patients with acute headache suggestive of aneurysmal subarachnoid hemorrhage when the non-contrast head CT is negative? Radiological Society of North America's 98th Scientific Assembly and Annual Meeting, 2012, Chicago, Illinois.

72. Saha BN, **Whitlow CT**, Kota G, Moody E, Natarajan S, Bowden D, Divers J, Freedman BI Maldjian JA.

Hierarchical level set with boosting for white matter lesion segmentation in diabetes. Radiological Society of North America's 98th Scientific Assembly and Annual Meeting, 2012, Chicago, Illinois.

73. Maldjian JA, **Whitlow CT**, Saha BN, Kota G, Moody EA, Bowden DW, Divers J, Freedman BI. Evaluation of automated white matter lesion segmentation in diabetes. Radiological Society of North America's 98th Scientific Assembly and Annual Meeting, 2012, Chicago, Illinois.

74. Natarajan S, Joshi S, Saha B, Edwards A, Khot T, Moody E, Kersting K, **Whitlow CT**, Maldjian JA. A machine learning pipeline for three-way classification of Alzheimer patients from structural magnetic resonance images of the brain. IEEE 11th International Conference on Machine Learning and Applications (ICMLA), 2012, Boca Raton, Florida.

75. Saha BN, Natarajan S, Kota G, **Whitlow CT**, Bowden DW, Divers J, Freedman BI, Maldjian JA. A novel hierarchical level set with AR-boost for white matter lesion segmentation in diabetes. IEEE 11th International Conference on Machine Learning and Applications (ICMLA), 2012, Boca Raton, Florida.

76. Maldjian JA, Davenport E, **Whitlow CT**, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Thompson MM, Urban J, Powers A, Stitzel J. An automated MEG resting-state analysis pipeline. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

77. Maldjian JA, Davenport E, **Whitlow CT**, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Thompson MM, Urban J, Powers A, Stitzel J. Graph theoretic MEG resting-state networks. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

78. Maldjian JA, Davenport E, **Whitlow CT**, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Thompson MM, Urban J, Powers A, Stitzel J. Stationarity of MEG and fMRI resting-state signal. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

79. **Whitlow CT.** Advanced Resting State Analysis and Research Applications: PCA, ICA, Graph Theory. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

80. Davenport EM, **Whitlow CT**, Powers A, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Thompson MM, Urban JE, Stitzel JD, Maldjian JA. Investigation of pediatric MEG networks using meta-ICA. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

81. Davenport EM, Urban JE, **Whitlow CT**, Powers A, Thompson MM, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Stitzel JD, Maldjian JA. Delta wave detection in MEG data of high school football players. American Society of Functional Neuroradiology 6th Annual Meeting, 2013, Charleston, South Carolina.

82. Marcus S, **Whitlow CT**, Koonce J, Zapadka ME, Chen MY, Williams DW, Lewis M, Evans AK. Computed tomography demonstrates abnormalities of contralateral ear in subjects with unilateral sensorineural hearing loss. American Society of Pediatric Otolaryngology Meeting, 2013, Arlington, Virginia.

83. Lillie EM, Urban JE, Lynch SK, **Whitlow CT**, Stitzel JD. Evaluation of the extent and distribution of diffuse axonal injury from real world motor vehicle crashes. Rocky Mountain Bioengineering Symposium (RMBS), 2013, Colorado Springs, Colorado.

84. Davenport EM, **Whitlow CT**, Powers A, Rawley J, McGowin I, Alberto G, Bungo T, Godwin D, Thompson MM, Urban JE, Stitzel JD, Maldjian JA. Investigation of pediatric MEG networks using meta-ICA. American Society of Neuroradiology 51st Annual Meeting, 2013, San Diego, California.

85. Davenport EM, Urban JE, **Whitlow CT**, Powers A, Thompson MM, Rawley J, McGowin I, Alberto G, Bungo

T, Godwin D, Stitzel JD, Maldjian JA. Delta wave detection in MEG data of high school football players. American Society of Neuroradiology 51st Annual Meeting, 2013, San Diego, California.

86. Marcus S, **Whitlow CT**, Koonce J, Zapadka ME, Chen MY, Williams DW, Lewis M, Evans AK. Computed tomography demonstrates morphologic abnormalities of the contralateral ear in subjects with unilateral sensorineural hearing loss. American Society of Pediatric Otolaryngology Annual Meeting, 2013, Washington DC.

87. Marcus S, **Whitlow CT**, Koonce J, Zapadka ME, Chen MY, Williams DW, Lewis M, Evans AK. Computed tomography supports histopathologic evidence of vestibulocochlear sexual dimorphism. American Society of Pediatric Otolaryngology Annual Meeting, 2013, Washington DC.

88. Reis JP, Launer LJ, Terry JG, Loria CM, Sidney S, Yaffe K, Jacobs DR, **Whitlow CT**, Zhu N, Carr JJ. Subclinical atherosclerosis and cognitive functioning in middle-aged black and white adults. American Heart Association's Nutrition, Physical Activity and Metabolism and Cardiovascular Disease Epidemiology and Prevention 2013 Scientific Meeting. New Orleans, Louisiana.

89. **Whitlow CT**, Maldjian JA. Neuroimaging and mild TBI. Advanced Technologies and New Frontiers in Brain Injuries and Biomechanics, 2013, Washington DC.

90. Tate J, Brashear A, **Whitlow CT**, Snively B, Ozelius L, Sweadner K, Stacy M, Haq I. Rapid-Onset Dystonia-Parkinsonism Presenting as Tremor-Dominant Parkinson's Disease. The American Academy of Neurology's 65th AAN Annual Meeting, 2013, San Diego, California.

91. Brashear A, Cook JF, Snively BM, Ozelius LJ, Sweadner KJ, **Whitlow CT**. Imaging results in RDP provide potential insights. Second Symposium on ATP1A3 in disease, 2013, Rome, Italy.

92. Bailey M, Richardson A, **Whitlow CT**. DSM V: Are there really no subtypes of schizophrenia anymore? Insights from MRI. 11th Annual American Medical Association Research Symposium, 2013, National Harbor, Maryland.

93. Sachs JR, **Whitlow CT**, Zapadka M. An algorithmic approach towards the evaluation of hypoxic-ischemic encephalopathy (HIE) in pediatric patients. Radiological Society of North America's 99th Scientific Assembly and Annual Meeting, 2013, Chicago, Illinois.

94. Urban JE, Davenport EM, Maldjian JA, **Whitlow CT**, Powers AK, Stitzel JD. "A Risk Weighted Cumulative Exposure Metric for the Analysis of Head Impact Data." American Academy of Neurology Sports Concussion Conference Poster Session, Chicago, IL, July 2014.

95. Bahrani N, Davenport EM, Urban JE, Stitzel JD, **Whitlow CT**, Jung Y, Maldjian JA. "Head Impacts and White Matter Changes in High School Football: A TBSS Analysis." 13th Annual Graduate Student Research Symposium, Winston Salem, NC, May 2014.

96. Mokhtari F, Davenport EM, Urban JE, **Whitlow CT**, Stizel JD, Maldjian JA. "Classifying Head-Impact Related Changes in Brain Connectivity a Support Vector Machine Recursive Feature Elimination Approach After a Single Season of High School Football." 13th Annual Graduate Student Research Symposium, Winston Salem, NC, May 2014.

97. Davenport EM, **Whitlow CT**, Urban JE, Espeland MA, Jung, Y, Rosenbaum DA, Vaughn CG, Gioia GA, Powers AK, Stitzel JD, Maldjian JA. "Abnormal White Matter Integrity Related to Head Impact Exposure in a Season of High School Varsity Football." 13th Annual Graduate Student Research Symposium, Winston Salem, NC, May 2014.

98. Mokhtari F, Davenport EM, Urban JE, Bahrami N, **Whitlow CT**, Powers AK, Stitzel JD, Maldjian JA. Interhemispheric Connectivity Changes Associated with a Season of High School Football. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

99. Urban JE, Miller LE, Davenport EM, Maldjian JA, **Whitlow CT**, Powers AK, Stitzel JD. Impact Location Relates to Areas of Increased Delta Wave Power in MEG Data of High School Football Players. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

100. Davenport E, **Whitlow C**, Urban J, Espeland M, Jung Y, Rosenbaum D, Gioia G, Powers A, Stitzel J, Maldjian J. White Matter Integrity Changes and Head Impact Exposure in a Season of High School Varsity Football. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

101. **Whitlow CT,** Padilla N, Mårtensson G, O'Shea TMD, Maldjian JA, Skiöld B, Blennow M, Vollmer B, Åden U. Patterns of Structural Co-Variance Associated with Autism Spectrum Disorder in Extremely Preterm Neonates: A Novel Voxel-Wise Graph Theoretic Approach. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

102. **Whitlow CT**. Advanced Resting State Analysis and Research Applications: PCA, ICA, Graph Theory. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

103. Maldjian JA, Davenport E, **Whitlow CT.** Graph Theoretic Connectivity Analysis of MEG data. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

104. Ackall F, Marcus S, **Whitlow CT**, Koonce J, Zapadka M, Chen M, Williams D, Lewis M, Evans A. Relationships of audiometric patterns in "idiopathic" hearing loss to subtle radiographic findings in "normal" temporal bone computed tomography. American Society of Pediatric Otolaryngology, 2014, Las Vegas, Nevada.

105. Urban J, Miller L, Davenport E, Maldjian J, **Whitlow CT**, Powers A, Stitzel J. Magnetoencephalographic Delta Wave Changes Related to Impact Location in High School Football. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

106. Davenport E, **Whitlow CT**, Urban J, Espeland M, Jung Y, Rosenbaum D, Gioia G, Powers A, Stitzel J, Maldjian J. White Matter Integrity Changes and Head Impact Exposure in a Season of High School Varsity Football. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

107. Mokhtari F, Davenport EM, Urban JE, Bahrami N, **Whitlow CT**, Powers AK, Stitzel JD, Maldjian JA. Interhemispheric Connectivity Changes Associated with a Season of High School Football. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

108. Maldjian JA, Davenport E, **Whitlow CT**. Graph Theoretic Connectivity Analysis of MEG data. American Society of Functional Neuroradiology 7th Annual Meeting, 2014, Miami, Florida.

109. **Whitlow CT.** Imaging the neonatal brain: Advanced MRI methods and analysis techniques. American Society of Neuroradiology 52nd Annual Meeting, 2014, Montreal, Quebec, Canada.

110. **Whitlow CT,** Padilla N, Mårtensson G, O'Shea TMD, Maldjian JA, Skiöld B, Blennow M, Vollmer B, Åden U. Patterns of Structural Co-Variance Associated with Autism Spectrum Disorder in Extremely Preterm Neonates: A Novel Voxel-Wise Graph Theoretic Approach. American Society of Neuroradiology 52nd

Annual Meeting, 2014, Montreal, Quebec, Canada.

111. Kurian A, **Whitlow CT**. Metabolic syndrome and Alzheimer's Disease: Exploring the role of obesity in the development of cognitive impairment using fMRI DMN output. American Roentgen Ray Society Annual Meeting, 2014, San Diego, CA.

112. Powers AK, Davenport EM, Urban JE, **Whitlow CT**, Espeland M, Maldjian JA, Jung Y, Stitzel JD. "Abnormal White Matter Integrity Related to Head Impact Exposure in a Season of High School Varsity Football." American Association of Neurological Surgeons, San Francisco, CA, April 2014.

113. Stitzel JD, Urban JE, Davenport EM, Maldjian JA, **Whitlow CT**, Powers AK, "Development of a Risk Weighted Cumulative Exposure Metric for the Analysis of Head Impact Data." International Brain Injury Association Tenth World Congress on Brain Injury, San Francisco, CA, March 2014.

114. Mokhtari F, Davenport EM, Urban JE, Bahrami N, **Whitlow CT**, Powers AK, Stitzel JD, Maldjian JA. Frontal Lobe Interhemispheric Connectivity Changes Associated with a Season of High School Football. International Society for Magnetic Resonance in Medicine 23rd Annual Meeting, 2014, Milan, Italy.

115. Padilla N, Eklof E, **Whitlow CT**, Mårtensson G, Lagercrantz H, Åden U. Autism spectrum disorder in ex-preterms is preceded by altered neonatal brain volumes and structural covariance. Pediatric Academic Societies Annual Meeting, 2014, Vancouver, BC.

116. **Whitlow CT.** Clinical Perspectives in fMRI: Current state of neuroradiologic applications for patient care. International Society for Magnetic Resonance in Medicine Scientific Workshop. Functional MRI: Emerging Techniques & New Interpretations, 2014, Charleston, SC.

117. **Whitlow CT**, Mokhtari F, Natarajan S, Maldjian JA. Classifying TBI-associated changes in interhemispheric network connectivity among high school football players using support vector machine recursive feature elimination. International Society for Magnetic Resonance in Medicine Scientific Workshop. Functional MRI: Emerging Techniques & New Interpretations, 2014, Charleston, SC.

118. Bahrami N, Davenport E, **Whitlow CT**, Urban J, Jung Y, Espeland M, Rosenbaum D, Vaughan C, Gioia G, Powers A, Stitzel J, Maldjian J. TBSS analysis of white matter changes related to head impacts in high school football. Biomedical Engineering Society Fall Scientific Meeting, 2014, San Antonio, Texas.

119. Aprakarian K, Davenport E, Urban J, Espeland M, **Whitlow CT**, Jung Y, Rosenbaum D, Powers A, Stitzel J, Maldjian JA. Axonal water fraction is related to head impact exposure in high school varsity football players. Biomedical Engineering Society Fall Scientific Meeting, 2014, San Antonio, Texas.

120. Mokhtari F, Davenport E, Urban J, **Whitlow CT**, Natarajan S, Stitzel J, Maldjian JA. Classifying head-impact related changes in brain connectivity after a single season of high school football: A support vector machine recursive feature elimination approach. Biomedical Engineering Society Fall Scientific Meeting, 2014, San Antonio, Texas.

121. Urban J, Weaver A, Lillie E, Maldjian J, **Whitlow C**, Stitzel J. Morphological changes in the adult skull with age and sex. Biomedical Engineering Society Annual Meeting, 2014, San Antonio, Texas.

122. Lesser GJ, Harmon M, Khan IU, **Whitlow CT**, Brown WR. Cellular microparticles as blood-borne endothelial biomarkers in patients with malignant gliomas. Society for Neuro-Oncology Annual Meeting, 2014, Miami, Florida.

123. Bahrami N, Sharma H, Davenport EM, Urban JE, Stitzel JD, Powers AK, **Whitlow CT**, Maldjian JA. Effects of

linear and rotational head impact on white matter changes in high school football players. International Society for Magnetic Resonance in Medicine (ISMRM), 2015, Toronto , Canada.

124. Sharma H, Davenport EM, Urban JE, Wagner B, Stitzel JD, Powers AK, Maldjian JA, **Whitlow CT**. Effect of head impact exposure on microstructural development of white matter tracts in a season of high school varsity football. International Society for Magnetic Resonance in Medicine (ISMRM), 2015, Toronto , Canada.

125. Sharma H, Davenport EM, Urban JE, Wagner B, Stitzel JD, Powers AK, Maldjian JA, **Whitlow CT**. Diffusion changes in cerebellar white matter microstructure related to head impact exposure in a season of high school varsity football. International Society for Magnetic Resonance in Medicine (ISMRM), 2015, Toronto , Canada.

126. Davenport EM, Urban JE, **Whitlow CT**, Espeland MA, Jung Y, Rosenbaum DA, Gioia GA, Powers AK, Stitzel JD, Maldjian JA. Head impact exposure in a season of youth football increases MEG low frequency brain waves. American Society of Neuroradiology 53nd Annual Meeting, 2015, Chicago, IL.

127. DellaGrotta LM, Davenport EM, Urban JE, Espeland MA, Jung Y, Gioia GA, Powers AK, Stitzel JD, Maldjian JA, **Whitlow CT**. Non-concussive cumulative head impact-associated abnormalities in brain gray matter after a single season of varsity high school football: practices versus games. American Society of Neuroradiology 53nd Annual Meeting, 2015, Chicago, IL.

128. Szuch ET, Davenport EM, Urban JE, Espeland MA, Jung Y, Gioia GA, Powers AK, Stitzel JD, Maldjian JA, **Whitlow CT**. Diffusional kurtosis imaging reveals head-impact associated changes in brain white matter after a single season of varsity high school football. American Society of Neuroradiology 53nd Annual Meeting, 2015, Chicago, IL.

129. Mokhtari F, Lack C, **Whitlow CT**, Stitzel JD, Maldjian JA. FMRI connectivity network changes associated with a season of high school football. American Society of Neuroradiology 53nd Annual Meeting, 2015 Chicago, IL.

130. Mokhtari F, Lack C, **Whitlow CT**, Stitzel JD, Maldjian JA. Discriminating between pre- and post-season fMRI connectivity networks after a single season of high school football: a machine learning study. American Society of Neuroradiology 53nd Annual Meeting, 2015 Chicago, IL.

131. Bahrami N, Sharma H, Davenport EM, Stitzel JD, Powers AK, **Whitlow CT**, Maldjian JA. Brain structural network changes related to head impact in youth football. American Society of Neuroradiology (ASNR), 2015, Chicago, IL.

132. Bahrami N, Sharma H, Davenport EM, Urban JE, Stitzel JD, Powers AK, **Whitlow CT**, Maldjian JA. Brain structural network changes related to head impact in youth football. American Society of Functional Neuroradiology (ASFNR), 2015, Tucson, AZ.

133. Sharma H, Davenport EM, Urban JE, Stitzel JD, Powers AK, **Whitlow CT**, Maldjian JA. Effects of head impact exposure on the internal and external capsule regions of white matter in high school varsity football players. American Society of Neuroradiology, 2015, Chicago, IL.

134. Mokhtari F, Lack C, **Whitlow CT**, Stitzel JD, Maldjian JA. Classification of pre- and post-season resting-state fMRI networks after a single season of high school football. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

135. Mokhtari F, Lack C, **Whitlow CT**, Stitzel JD, Maldjian JA. Effects of subconcussive head impacts in a single

season of high school football on resting-state fMRI connectivity networks. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

136. Bahrami N, Sharma H, **Whitlow CT**, Urban JE, Espeland MA, Jung Y, Rosenbaum DA, Gioia GA, Powers AK, Stitzel JD, Maldjian JA. Brain structural network changes related to head impact in youth football. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

137. Davenport EM, Urban JE, **Whitlow CT**, Espeland MA, Jung Y, Rosenbaum DA, Gioia GA, Powers AK, Stitzel JD, Maldjian JA. Season of youth football increases MEG low frequency brain waves. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

138. **Whitlow CT**. Resting state connectivity analyses: PCA, ICA, and graph theory. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

139. **Whitlow CT**. Dynamic functional connectivity of the resting state. American Society of Functional Neuroradiology 9th Annual Meeting, 2015, Tucson, AZ.

140. **Whitlow CT**. Normative Databases and Machine Learning: Does it Matter for Neuroradiology? American Society of Neuroradiology 53nd Annual Meeting. Omics and Big Data for Neuroradiology Minisymposium,2015, Chicago, IL.

141. **Whitlow CT**. Managing Big Data from MRI: the Neuroradiologist's Perspective. International Society for Magnetic Resonance in Medicine 23rd Annual Meeting. Genomics, Proteomics, & Big Data Course. 2015, Toronto, ON, Canada.

MEDICAL STUDENTS/GRADUATE STUDENTS/RESIDENTS/FELLOWS ADVISED

WFUSM Medical Students:

2010-Present Mentor for Research Projects

2010-2012	Jenny Soun Class of 2012
2010-2012	Kavya Reddy Class of 2012
2010-2012	Pavani Thotakura Class of 2012
2011-2013	Alec Richardson Class of 2013
2011-2013	Whitney Feltus Class of 2013
2011-2013	Candace Curry Class of 2013
2011-2013	Sonya Marcus Class of 2013

2011-Present	Greg Westcott Class of 2014
2012-Present	Mark Bailey Class of 2014
2012-Present	Shivank Garg Class of 2014
2013-Present	Daniel Cook Class of 2016
2013-Present	Tramaine Wilkinson Class of 2016
2013-Present	Chandler Fountain Class of 2017
2013-Present	Lynn DellaGrotta Class of 2017
2014-Present	Ann Liu Class of 2015
2014-Present	Eliza Szuch Class of 2018
2015-Present	Scott Rosenthal Class of 2018
2015-Present	Eileen Libove Class of 2018

2010-Present WFUSM Graduate Students:

2011-Present	Jillian Urban Biomedical Engineering Program Master's Thesis Committee and Doctoral Thesis Committee
2011-Present	Elizabeth Davenport Biomedical Engineering Program Co-research advisor; Doctoral Thesis Committee
2011-Present	Megan Johnson Biomedical Engineering Program Research consultant; Doctoral Thesis Committee
2013-Present	Bryan Neth MD/PhD Neuroscience Program Co-research advisor; Doctoral Thesis Committee
2013-Present	Fatehmeh Mokhtari

Biomedical Engineering Program
Co-research advisor

2013-Present Naeim Bahrami
Biomedical Engineering Program
Co-research advisor

2011-Present Elaine Shing
MD/PhD Neuroscience Program
Chair, Doctoral Thesis Committee

2010-Present Medical Students/Residents/Fellows:

2010-Present Faculty Mentor, Neuroradiology Fellowship Program
Supervise 4 neuroradiology fellows each year

2012-Present Director, MD/PhD Program
Supervise 17 MD/PhD students each year

2013-Present Mentor, Medical Student Learning Community
Supervise 30 medical students in "House Mentorship Program" each year

2010-Present Visiting International Medical Students/Trainees:

2010-2011 Fabricio Goncalves
Neuroradiology Fellow
University of Toronto

2013-Present Anna Kurian
Medical Student
University of the Caribbean School of Medicine

Medical Student Grant Funding:

1. 2015 Research Medical Student Grant Application - RSNA R&E Foundation
Title: Associations between Whole Brain Network Connectivity and Cognitive Function in African Americans with Type-2 Diabetes Mellitus: A Resting-State Functional MRI Graph Theoretical Analysis.
Student: Daniel Cook
Faculty Advisor/Mentor: Christopher T. Whitlow, MD, PhD, MHA

2. 2015 Medical Student Research Program – Wake Forest School of Medicine
Title: Form and Function in Normal Brain Development: A Combined Magnetoencephalography and Magnetic Resonance Imaging Investigation across Childhood and Adolescence
Student: Eileen Libove
Faculty Advisor/Mentor: Christopher T. Whitlow, MD, PhD, MHA

3. 2015 Medical Student Research Program – Wake Forest School of Medicine
Title: Effects of Sports-Related Cumulative Head Impact Exposure on Cognitive Function and Brain Microstructural Integrity
Student: Scott Rosenthal
Faculty Advisor/Mentor: Christopher T. Whitlow, MD, PhD, MHA