

SAMSI NDA Final Report

1. Background:

Purpose & objectives.

The term "Neuroimaging Data Analysis" (NDA) is aimed at encompassing a broad array of imaging, mathematical, and statistical methods for the analysis of neuroimaging data. This SAMSI program seeks to bring together a diverse group of researchers from different disciplines including statistics, mathematics, computer science, biomedical engineering, psychiatry, psychology, neuroscience, and radiology, among other related sciences, to explore the common structure that underlies such methodologies, and to use this knowledge in turn to motivate and synthesize new approaches.

The SAMSI NDA program was motivated by the great need in the analysis of high-dimensional, correlated, and complex neuroimaging data and clinical and genetic data obtained from various cross-sectional and clustered neuroimaging studies. These neuroimaging studies are essential to understanding the neural development of neuropsychiatric and neurodegenerative disorders, substance use disorders, the normal brain and the interactive effects of environmental and genetic factors on brain structure and function. Particularly, NIH devotes great efforts on creating secure research data repositories for promoting scientific brain imaging data sharing and collaboration among scientists and institutions for new discoveries through enhanced statistical power, innovative and multi-level analyses, and data modeling.

Yet, analyzing such high-dimensional, correlated, and complex neuroimaging data represents both theoretical and computational challenges. Furthermore, it is much more difficult to develop appropriate mathematical and statistical tools to jointly model complex imaging, clinical, and genetic data, which is critical to interpreting the findings from any neuroimaging studies. The development of such methods for analyzing imaging data itself and integrating imaging data with genetic and clinical data has fallen seriously behind the technological advances on genomics and neuroimaging. In contrast, only a handful of mathematicians and statisticians are working full time on neuroimaging data analysis. To meet this critical and important need and challenge, we use the SAMSI NDA program to serve as a platform for bringing the leading figures in NDA, exchanging new research ideas, and training the next-generation mathematicians and statisticians in the field of NDA.

Organizers & key personnel

The co-chairs of the Program include **Jane-Ling Wang** (Email: janelwang@ucdavis.edu) from UC-Davis, Robert E. Kass (Email: kass@stat.cmu.edu) from CMU, and Haipeng Shen (Email: haipeng@email.unc.edu), and Hongtu Zhu (Email: htzhu@email.unc.edu), from UNC-CH.

Directorate Liaison:

Ezra Miller

Program Committee:

- John Aston, Warwick (Statistics)
- F. DuBois Bowman, Emory (Biostatistics)
- Brian Caffo, John Hopkins (Statistics)
- David Isaacson, Rensselaer (Medical Imaging)
- Robert E. Kass, Carnegie Mellon (Statistics)
- Nicole Lazar, U. Georgia (Statistics)
- Jeffery Morris, Anderson Cancer Center (Bioinformatics)
- Hernando C. Ombao, UC Irvine (Statistics)
- Kui Ren, UT Austin (Mathematics)
- Daniel Rowe, Marquette (Math Stat and CS -- fMRI lab)
- Haipeng Shen, UNC-CH (Statistics)
- Gunther Uhlmann, U Washington (Math)
- Jane-Ling Wang, UC-Davis (Statistics)
- Chunming Zhang, U. Wisconsin (Statistics)
- Hongtu Zhu, UNC-CH (Biostatistics)

2. Training Course

Objectives: We organized one four-day short course on structural and functional neuroimaging data analyses from June 4 to June 7 at the SAMSI headquarter.

The two major objectives of this training course are

- train next-generation statisticians and mathematicians on NDA;
- master statistical and mathematical methods in the analysis of neuroimaging data.

Themes/Topics: The lecture contents include the major scientific questions, mathematical and statistical methods, and their applications.

- In the first two days, we are focused on structural NDA. Specifically, we will cover the statistical and mathematical methods associated with imaging reconstruction, imaging segmentation, and imaging registration, and their applications.
- In the last two days, we are focused on functional NDA. Since imaging segmentation and registration have been covered in the first two days, we will focus on several unique topics for functional NDA. Specifically, we will cover the

statistical and mathematical methods associated with imaging reconstruction, and group analysis, and their applications.

Prerequisites: Basic knowledge of calculus, differential equation, and linear regression.

Organizers: The following instructors taught the courses:

- Dinggang Shen, UNC-Radiology, MRI
- Marc Niethammer, UNC-Computer Science, MRI
- Martin Styner, UNC-CS and Psychiatry, DTI
- Hongtu Zhu, UNC-Biostatistics, DTI
- Martin Lindquist, JHU Biostatistics, fMRI
- F. DuBois Bowman, Emory Biostatistics, fMRI
- John Aston, Warwick, PET
- Ombao C. Hernando, University of California at Irvine, EEG/MEG

Audience: We accepted about 40 participants for Week 1 and put another 10 applicants on the waiting list. Among them, 7 participants came from local universities and 33 participants came from outside. Almost all participants are statisticians and mathematicians. During Week 1, 10 local participants on the waiting list also attended the training course.

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Winkler	Anderson	andersonwinkler@gmail.com	Univ. of Oxford
Shi	Jian	j.q.shi@ncl.ac.uk	Newcastle University

Schedule: The schedule is given as follows:

June 4: Structural Neuroimaging Data Analysis (Day 1)

- 8:30am-9:20am: Introduction. Hongtu Zhu
- 9:20am-9:50am: Break.
- 9:50am-10:40am: Reconstruction. Hongtu Zhu
- 10:40am-11:10am: Break.
- 11:10am-12:00pm: Reconstruction. Hongtu Zhu
- 12:00pm-1:30pm: Lunch Break.
- 1:30pm-2:20pm: Segmentation. Marc Niethammer.
- 2:20pm-2:50pm: Break.
- 2:50pm-3:40pm: Segmentation. Marc Niethammer.
- 3:40pm-4:10pm: Break.
- 4:10pm-5:00pm: Problem/discussion sessions.

June 5: Structural Neuroimaging Data Analysis (Day 2)

- 8:30am-9:20am: Registration. Dinggang Shen
- 9:20am-9:50am: Break.

- 9:50am-10:40am: Registration. Dinggang Shen
- 10:40am-11:10am: Break.
- 11:10am-12:00pm: Registration. Dinggang Shen
- 12:00pm-1:30pm: Lunch Break.
- 1:30pm-2:20pm: Applications. Ipek Oguz and Martin Styner
- 2:20pm-2:50pm: Break.
- 2:50pm-3:40pm: Applications. Ipek Oguz and Martin Styner
- 3:40pm-4:10pm: Break.
- 4:10pm-5:00pm: Problem/discussion sessions.

June 6: Functional Neuroimaging Data Analysis. (Day 1)

- 8:30am-9:20am: Introduction. F. DuBois Bowman
- 9:20am-9:50am: Break.
- 9:50am-10:40am: Introduction. F. DuBois Bowman
- 10:40am-11:10am: Break.
- 11:10am-12:00pm: Reconstruction. Martin Lindquist
- 12:00pm-1:30pm: Lunch Break.
- 1:30pm-2:20pm: Reconstruction. Martin Lindquist
- 2:20pm-2:50pm: Break.
- 2:50pm-3:40pm: Reconstruction. Martin Lindquist
- 3:40pm-4:10pm: Break.
- 4:10pm-5:00pm: Problem/discussion sessions.

June 7: Functional Neuroimaging Data Analysis. (Day 2)

- 8:30am-9:20am: Group Analysis. John Aston
- 9:20am-9:50am: Break.
- 9:50am-10:40am: Group Analysis. John Aston
- 10:40am-11:10am: Break.
- 11:10am-12:00pm: Group Analysis. John Aston
- 12:00pm-1:30pm: Lunch Break.
- 1:30pm-2:20pm: Applications. Ombao C. Hernando
- 2:20pm-2:50pm: Break.
- 2:50pm-3:40pm: Applications. Ombao C. Hernando
- 3:40pm-4:10pm: Break.

- 4:10pm-5:00pm: Problem/discussion sessions.



Highlights: There are several major highlights:

- All participants highly agreed that the lecture contents were closely associated with their own research;
- All participants strongly agreed that the instructors were effective and handled questions well;
- All participants highly agrees that this training course provides an unique opportunity and a fast way for them to get into NDA.
- All instructors are leading figures in the related field.
- Among the participants, there are several leading figures in statistics, such as Wang Naisyin or Huang Jianhua. They plan to offer similar courses in their universities.

3. Oral Presentation

Objectives: We organized 20 oral presentations from June 9 to June 14 and a poster session on June 10. The three major aims of oral presentations are

- train next-generation statisticians and mathematicians on NDA;
- learn from the leading researchers from other disciplines including biomedical engineering, psychiatry, psychology, neuroscience, and radiology on NDA;
- provide a platform for statisticians and mathematicians with extensive experience on NDA to share their knowledge.

We invited 20 distinguished speakers to address major areas and cutting edge research of NDA. We had 4 talks per day and a post-presentation session on June 10. All speakers come from applied mathematics, statistics, computer science, biomedical engineering, psychiatry, psychology, and neuroscience.

Organizers of the Program include **Jane-Ling Wang** (Email: janelwang@ucdavis.edu) from UC-Davis, Robert E. Kass (Email: kass@stat.cmu.edu) from CMU, and Haipeng Shen (Email: haipeng@email.unc.edu), and Hongtu Zhu (Email: htzhu@email.unc.edu), from UNC-CH.

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[Ezra Miller](#)

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- Jeffery Morris, Anderson Cancer Center (Bioinformatics)
- Hernando C. Ombao, UC Irvine (Statistics)
- Kui Ren, UT Austin (Mathematics)
- Daniel Rowe, Marquette (Math Stat and CS -- fMRI lab)
- Haipeng Shen, UNC-CH (Statistics)
- Gunther Uhlmann, U Washington (Math)
- Jane-Ling Wang, UC-Davis (Statistics)
- Chunming Zhang, U. Wisconsin (Statistics)
- Hongtu Zhu, UNC-CH (Biostatistics)

Audience: We accepted about 40 participants for Week 2 and put another 10 applicants on the waiting list. Among them, 7 participants came from local universities and 33 participants came from outside. Almost all participants are statisticians and mathematicians. During Week 2, 10 additional participants also attended the training course.

Aston	John	University of Warwick
Chung	Moo	University of Wisconsin-Madison
Crainiceanu	Ciprian	Johns Hopkins Bloomberg School of Public Health
Johnson	Timothy	University of Michigan
Kass	Rob	Carnegie Mellon University
Lindquist	Martin	Johns Hopkins University
Nichols	Thomas	University of warwick
Ombao	Hernando	Univ California at Irvine

Rowe	Daniel	Marquette University
Wang	Jane-Ling	Univ of California at Davis
Gallant	Jack	UC Berkeley
Lazar	Nicole	University of Georgia
Zhu	Hongtu	UNC-Chapel Hill
Miller	Ezra	SAMSI and Duke University
Ye	Jieping	Arizona State University
Shen	Haipeng	University of North Carolina at Chapel Hill
Gilmore	John	UNC School of Medicine
Daubechies	Ingrid	Duke
Willett	Rebecca	Duke
Younes	Laurent	Johns Hopkins
Sajda	Paul	Columbia
Chungming	Zhang	Wiscosin Madisson
Caffo	Brian	Johns Hopkins Bloomberg School of Public Health
Cao	Yan	University of Texas at Dallas
Lee	Seonjoo	The Henry Jackson Foundation
Marron	Steve	UNC
Mueller	Hans-Georg	UC Davis
Reiss	Philip	New York University
Roy Choudhury	Kingshuk	Duke University
Simpson	Sean	Wake Forest School of Medicine
Su	Jingyong	Florida State University
Tian	Tian	University of Houston
Vogelstein	Joshua	Duke University
Wang	Dong	UNC-Chapel Hill
Xie	Qian	Florida State University
Yuan	Ying	St. Jude children's research hospital
Zhang	Yajing	Johns Hopkins University
Zhang	Jing	Yale University
Zipunnikov	Vadim	Johns Hopkins Bloomberg School of Public Health
Huang	Jianhua	Texas A&M University
Ivanescu	Andrada	East Carolina University
Jiang	Bei	University of Michigan
Kurtek	Sebastian	Ohio State University
Luo	Shikai	NCSU
Mehta	Chintan	Princeton University
Zhang	Tingting	University of Virginia
Winkler	Anderson	Univ. of Oxford
Fan	Yong	Institute of Automation Chinese Academy of Sciences
Guillaume	Bryan	University of Warwick
Kong	Linglong	University of Alberta
		Weierstrass Institute for Applied Analysis and Stochastics
Polzehl	Joerg	(WIAS)

Solo

Victor

University of New South Wales

Schedule: The schedule is given as follows:

June 9, 2013, Sunday

9:30-10:00 Introduction

Hongtu Zhu, University of North Carolina

10:00-10:30 **Joerg Polzehl**, Weierstrass Institute for Applied Analysis and Stochastics
(WIAS)

Position Orientation Adaptive Smoothing (POAS) in Diffusion Weighted Imaging

10:45-11:15 **Dinggang Shen**, University of North Carolina

Groupwise Image Registration and Segmentation

11:30-12:00 **Jieping Ye**, Arizona State University

Large-Scale Sparse Learning for Neuroimaging Data

June 10, 2013, Monday

8:30-9:10 **John Gilmore**, University of North Carolina

Early-childhood Imaging and Risk for Psychiatric Disease

9:35-10:05 **Rob Kass**, Carnegie Mellon University

Statistics in Neuroscience: The Case of Neural Spike Trains

10:40-11:10 **Jack Gallant**, UC-Berkeley

Voxel-wise Modeling and Decoding (VWMD)

11:20-12:00 **Paul Sajda**, Columbia University

Multimodal Neuroimaging of Perceptual Decision Making

5:00-6:30 Poster Session

June 12, 2013, Wednesday

8:30-9:10 **Ingrid Daubechies**, Duke University

Cortex-adapted Wavelets for fMRI

9:35-10:05 **Laurent Younes**, Johns Hopkins
[Recent Advances in Computational Anatomy](#)

10:40-11:10 **Victor Solo**, University of New South Wales
[Granger Causality and fMRI](#)

11:20-12:00 **Rebecca Willett**, Duke University
[Oracle Inequalities and Minimax Rates for Non-local Means](#)

June 13, 2013, Thursday

8:30-9:10 **Moo Chung**, University of Wisconsin
[Exploiting Hidden Persistent Homology in Multivariate Tensor-Based Morphometry and its Application to Detecting White Matter Abnormality in Abused Children](#)

9:35--10:05 **Timothy Johnson**, University of Michigan
[New Statistical Approaches to Neuroimaging Meta-Analysis](#)

10:40-11:10 **Martin Lindquist**, Johns Hopkins
Connectivity and Causality in Brain Imaging

11:20-12:00 **Ciprian Crainiceanu**, Johns Hopkins
[Statistical Methods for High-Resolution Multi-Sequence MRI](#)

June 14, 2013, Friday

8:30-9:10 **Thomas Nichols**, University of Warwick
Imaging Genetics: Big Data Squared

9:35-10:05 **Nicole Lazar**, University of Georgia
[Statistical Challenges in the Analysis of Group Imaging Data](#)

10:40-11:10 **Chunming Zhang**, University of Wisconsin
[Multiple Comparison With Applications In Neuroimaging Data](#)

11:20-12:00 **Daniel Rowe**, Marquette University
[Is My Correlation of Biological Origin?](#)

Other activities:

NDA has a poster session in the SAMSI head quarter on June 10, 2013. There are around 20 posters presented by participants from different groups. All presenters actively interacted with

other participants by presenting their posters, answering questions, and discussing future research. These extensive discussions will lead to potential collaborations in the future.

NDA committee and Statistics in Imaging (SI) Session had a committee lunch meeting. This meeting was led by Timothy Johnson, Ciprian Crainiceanu, and Hongtu Zhu. During the meeting, participants discussed several major items given as follows:

- The strategies of increasing the collaboration among statisticians on NDA.
- The strategies of attracting more statisticians and mathematicians into NDA.
- The strategies of increasing new hiring associated with NDA.
- The strategies of involving NIH and NSF review process.
- The possibility of organizing more workshops and invited sessions in different conferences.
- The strategies of raising more funds for SI.

Highlights:

- All speakers are leading figures in the related topics.
- All participants highly agreed that the oral presentations are excellent and stimulating and cover a wide range of important neuroimaging problems associated with statistics and mathematics.
- All participants highly agreed that all speakers handled questions very well;
- All participants highly agreed that attending all oral presentations opened their view about neuroimaging studies and related mathematical and statistical issues.
- All participants highly agreed that they learnt from each other and found some interesting problems to work on.

4. Working Group

To enable more fruitful discussions on cutting-edge research topics, the NDA workshop participants are asked to sign up for the following four working groups (WG) according to research interests:

- WG1. Group Analysis (Chairs: Hongtu Zhu, UNC-CH and Tingting Zhang, Virginia)
- WG2. Imaging Registration (Chairs: Steve Marron, UNC-CH and Marc Niethammer, UNC-CH)
- WG3. Connectivity Analysis (Chairs: Daniel Rowes, Marquette and Jing Zhang, Yale)
- WG4. Multimodal Analysis (Chairs: Ombao Hernando, UC Irvine and Martin Lindquist, Johns Hopkins)

The working group portion happened during Week 2 of the workshop, Sunday June 9-Friday June 14, 2013. Each WG met for about 90 minutes each day for six days in a row. On each day, WG1 and WG2 met during the first time slot, while WG3 and WG4 met during the second time slot.

All working group leaders were present in the two-week period. Each working group discussed several important issues including existing approaches and their limitations, the cutting-edge research questions, important mathematical and statistical methods for solving those questions, and collaborations among group members. Each WG served the following purposes:

- introduce junior researchers to a new research area
- allow for in-depth expert discussions on the research topic
- identify important research problems within the area
- stimulate collaborations among participants with different expertise, which would have been impossible or difficult otherwise.

Although slightly different among the WGs, each of the six days of the workgroup consisted of one or two speakers covering a particular topic related to the WG topic in an informal setting, thereby enabling productive discussion throughout the talk and giving novices the ability to ask basic, clarifying questions to quickly get up to speed in this research area.

Feedbacks from the WG participants suggest that the WGs served the above purposes well, and the participants really appreciated the venue provided by SAMSI.

WG1: Group Analysis

This group mainly discusses mathematical and statistical methods associated with statistical group analysis and imaging genetics. The two WG chairs are Hongtu Zhu (UNC-CH, Biostatistics) and Tingting Zhang (UVA, Statistics).

The following topics are discussed:

- **Meta Analysis:**
 - Tom Nicolas, Tim Johnson, Martin Lindquist provided an excellent introduction of meta analysis in NDA, surveyed the current literature, and led a thoughtful discussion about interesting research problems in meta analysis of NDA.
- **Subject Heterogeneity/Group Analysis**
 - Linglong Kong gave a talk on varying coefficient models in DTI data analysis.
 - Tom Nichols gave a talk on model selection of multiregression dynamic models with application to resting state fMRI.
 - Hongtu Zhu gave a talk on diseased region detection longitudinal Knee MRI data
- **Bayesian Analysis:**
 - Jian Kang spoke about Bayesian meta analysis.

- Fan Li talked about Bayesian spatial selection and clustering for fMRI data with GPU programming.
- Pattern Recognition, led by talks from
 - Jieping Ye talked about fast regularization methods;
 - Yong Fang talked about machine learning methods in neuroimaging data;
 - Phil Reiss talked about function linear model framework;
 - Moo Chung talked about persistent homological approach in neuroimaging data.
- Longitudinal Data, led by talks from
 - Tom Nichols talked about estimating equations for neuroimaging data.
 - Hongtu Zhu talked about longitudinal varying coefficient model.
 - Ana-Maria Staicu talked about longitudinal functional principal component model.
- Functional Data:
 - Jane-Ling Wang delivered an introduction lecture on functional data analysis (FDA).
 - Martin Lindquist spoke about several of his research projects about neuroimaging analysis, which benefited greatly from FDA tools and ideas.
 - Tingting Zhang presented some recent work about semi-parametric hemodynamic function estimation with latency differences.

Participants:

- Fan Li, Statistics, Duke
- Ana-Maria Staicu, Statistics, NC State
- Martin Lingquist, Biostatistics, John Hopkins
- Hongtu Zhu, Biostatistics, UNC-CH
- Linglong Kong, Mathematical and Statistical Sciences, U. Alberta
- Jane-Ling Wang, Statistics, UC Davis
- Nicole Lazar, Statistics, UGA
- Yan Cao, Mathematics, UT Dallas
- Victor Solo, Electrical Engineering, University of New South Wales
- Tim Johnson, Biostatistics, Michigan
- John Aston, Statistics, Warwick
- Guillaume Bryan, Statistics, Warwick
- Jianhua Huang, Statistics, Texas A&M
- Haipeng Shen, STOR, UNC-CH
- Dan Yang, Statistics, SAMSI/UNC-CH
- Siva Tian, Psychology, U Houston
- Andrada Ivanescu, East Carolina U.
- Beibei Jiang, Statistics, Michigan
- Shikai Luo, NC State
- Anderson Winkler, Oxford
- Tingting Zhang, Statistics, UVa
- Phil Reiss, NYU
- Kingshuk Roy Choudhury, Duke

- Jingyong Su, Florida State
- Joshua Vogelstein, Statistics, Duke
- Ying Yuan, St. Jude Children's Research Hospital
- Jing Zhang, Statistics, Yale
- Moo Chung, Statistics, U Wisconsin-Madison
- Ciprian Crainiceanu, Biostatistics, John Hopkins
- Ingrid Daubechies, Mathematics, Duke
- Tom Nicols, Statistics, Warwick
- Dan Rowe, CS, Marquette
- Victor Solo, Electrical Engineering, University of New South Wales
- Jieping Ye, Arizona State
- Jian Kang, Biostatistics, Emory

WG2: Imaging Registration

This group mainly discusses mathematical and statistical methods associated with imaging registration, a key component for many medical image analysis tasks. The two chairs are Steve Marron (UNC-CH, Statistics and Operations Research) and Marc Niethammer (UNC-CH, CS)

As registration is a big area of research, the speakers were chosen to cover a wide range of representative topics. In particular, we had

- Sebastian Kurtek spoke on registration in Shape Analysis discussing metrics on the space of shapes.
- Sam Gerber gave an excellent overview on Manifold Learning related to image-valued data. This talk prompted discussions on spectral embeddings.
- As a result, Moo Chung gave a presentation on conjectured, but so far unproven properties of spectral embeddings.
- Laurent Younes gave a general introduction to the large displacement diffeomorphic metric mapping (LDDMM) paradigm of image registration, which greatly helped participants' understanding of this rather complex sub-area of image registration.
- Pei Zhang and Guorong Wu spoke on image registration for diffusion weighted images and for large datasets respectively which used the LDDMM formalism.
- Elizabeth Sweeney covered practical aspects of registration in multiple sclerosis which raised interesting discussions on the practical applicability of deformable registration algorithms in the context of pathologies.
- Enrique Dunn covered aspects of image registration in computer vision. While not specifically targeted towards medical imaging, his talk facilitated a discussion on how to reliably fit parametric models to data, which is highly relevant to allow for the robust registration of medical images.

Overall, the workgroup was a success, averaged between 10-15 participants per day and served the dual purpose of introducing junior researchers to a new research area and allowing for in-depth expert discussions on topics of image registration.

Participants:

- Moo Chung, Statistics, U Wisconsin-Madison
- Yajing Zhang, John Hopkins
- Dong Wang, STOR, UNC-CH
- Yan Cao, Mathematics, UT Dallas
- Joerg Polzehl, Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
- Beibei Jiang, Statistics, Michigan
- Sebastian Kurtek, Statistics, Ohio State
- Chintan Mehta, Princeton
- Hans Muller, Statistics, UC Davis
- Qian Xie, FSU
- Yong Fan, Chinese Academy of Sciences
- Sam Gerber, Mathematics, Duke University
- Laurent Younes, Applied Mathematics and Statistics, Johns Hopkins University
- Pei Zhang, UNC-Chapel Hill
- Guorong Wu, UNC-Chapel Hill
- Elizabeth Sweeney, Biostatistics, Johns Hopkins University
- Enrique Dunn, Computer Science, UNC-CH

WG3: Connectivity Analysis

This group mainly discusses mathematical and statistical methods associated with structural and functional connectivity analysis. The two chairs are Daniel Rowes (Marquette, CS) and Jing Zhang (Yale, Statistics).

The following presentations are given

- Brian Caffo, Moo Chung, Joerg Polzehl, Daniel Rowe reviewed several topics in brain connectivity.
- Tingting Zhang discussed effective connectivity and dynamic causal modeling.
- Tom Nichols, Martin Lindquist, Jing Zhang led a discussion about statistical inference of dynamic of functional connectivity.
- Seonjoo Lee spoke about modeling temporal dynamics in ICA.
- Josh Vogelstein, Phil Reiss, Tingting Zhang, Brian Caffo spoke about temporal dynamics in fMRI.
- Ciprian Crainiceanu and John Aston discussed structural MRI and connectivity.
- Sean Simpson led an interesting session about modeling and comparing complex functional brain networks.

Participants:

- Phil Reiss, NYU

- Martin Lingquist, Biostatistics, John Hopkins
- Hongtu Zhu, Biostatistics, UNC-CH
- John Aston, Statistics, U. Warwick
- Linglong Kong, Mathematical and Statistical Sciences, U. Alberta
- Jane-Ling Wang, Statistics, UC Davis
- Jing Zhang, Statistics, Yale
- Chunming Zhang, Statistics/CS, U. Wisconsin-Madison
- Yajing Zhang, John Hopkins
- Nicole Lazar, Statistics, UGA
- Yan Cao, Mathematics, UT Dallas
- Seonjoo Lee, Psychiatry/Biostatistics, Columbia
- Joerg Polzehl, Weierstrass Institute for Applied Analysis and Stochastics (WIAS)
- Victor Solo, Electrical Engineering, University of New South Wales
- Guillaume Bryan, Statistics, Warwick
- Jianhua Huang, Statistics, Texas A&M
- Haipeng Shen, STOR, UNC-CH
- Dan Yang, Statistics, SAMSI/UNC-CH
- Siva Tian, Psychology, U Houston
- Anderson Winkler, Oxford
- Sean Simpson, Wake Forest School of Medicine
- Tingting Zhang, Statistics, UVa
- Brian Caffo, Biostatistics, John Hopkins
- Hans Muller, Statistics, UC Davis
- Kingshuk Roy Choudhury, Duke
- Joshua Vogelstein, Statistics, Duke
- Ying Yuan, St. Jude Children's Research Hospital
- Moo Chung, Statistics, U Wisconsin-Madison
- Ingrid Daubechies, Mathematics, Duke
- Tom Nicols, Statistics, Warwick
- Dan Rowe, CS, Marquette
- Victor Solo, Electrical Engineering, University of New South Wales
- Rebecca Willett, EE, Duke
- Elizabeth Sweeney, Biostatistics, Johns Hopkins University
- Ciprian Crainiceanu, Biostatistics, Johns Hopkins

WG4: Multimodal Analysis

This group mainly discusses mathematical and statistical methods associated with imaging reconstruction and segmentation, and multimodal analysis. The two chairs are Ombao Hernando (UC Irvine, Statistics) and Martin Lindquist (Johns Hopkins, Biostatistics).

The following research topics are discussed

- Hernando Ombao, John Aston, Victor Solo led a discussion about multimodal analysis using EEG and fMRI.
- John Aston talked about partial volume correction using multimodal PET and MRI.
- Rob Kass talked about LFP and neuro spike train.
- Martin Lindquist talked about multimodal analysis using DTI and fMRI.
- Martin Lindquist led yet another discussion about combining imaging data with behavior data.
- Ciprian Crainiceanu spoke about multisequence structural MRI.
- Tom Nichols, Ja-an Lin, and Hongtu Zhu presented some imaging genetics research where fMRI data are combined with genetics data, and discussed what the challenges are.

Participants:

- Hernando Ombao, Statistics, UC Irvine
- Rob Kass, Statistics, CMU
- Martin Lingquist, Biostatistics, John Hopkins
- Sebastian Kurtek, Statistics, Ohio State University
- Dong Wang, STOR, UNC-CH
- John Aston, Statistics, U. Warwick
- Yan Cao, Mathematics, UT Dallas
- Victor Solo, Electrical Engineering, University of New South Wales
- Tim Johnson, Biostatistics, Michigan
- Haipeng Shen, STOR, UNC-CH
- Andrada Ivanescu, East Carolina U.
- Chintan Mehta, Princeton
- Anderson Winkler, Oxford
- Tingting Zhang, Statistics, UVa
- Brian Caffo, Biostatistics, John Hopkins
- Linglong Kong, Mathematical and Statistical Sciences, U. Alberta
- Phil Reiss, NYU
- Jingyong Su, Florida State
- Qian Xie, FSU
- Yong Fan, Chinese Academy of Sciences
- Ying Yuan, St. Jude Children's Research Hospital
- Jane-Ling Wang, Statistics, UC Davis
- Ciprian Crainiceanu, Biostatistics, John Hopkins
- Paul Saja, Columbia
- Jieping Ye, Arizona State

Initiated Collaborations

Another success of the NDA workshop is to get people with different expertise to start working together. Due to time limitation, no papers have resulted from the workshop, but many researchers have initiated research collaborations. Several examples are provided below:

- Hongtu Zhu and Jing Zhang talked about possible collaboration about Bayesian inference on Dynamics of functional connectivity.
- Hongtu Zhu, Ying Yuan, Kehui Chen, and Jane-Ling Wang have collaborated two papers on longitudinal functional data analysis.
- Tom Nichols and Jing Zhang discussed research about the change point (dramatic change) of graph modeling functional connectivity and smooth change of time-varying graph of connectivity.
- Chunming Zhang and Jing Zhang are interested in collaborating on the estimation of causality of linear structure equations.
- Yong Fan and Jing Zhang want to combine Jing's Dynamic Bayesian partition model with ICA.
- Tingting Zhang, Fan Li and Jing Zhang also talked about collaboration possibilities.
- Tingting Zhang, Jingwei Wu, Fan Li, Dana Boatman, Brian Caffo are inspired by the workshop to work on effective brain connectivity.
- Nicole Lazar indicated that she would work with Dan Rowe and Ezra Miller on two separate projects.
- Yan Cao really appreciated the opportunity to participate in the workshop, and indicated that she discussed with several people for possible collaborations during the workshop and would follow up in the future.
- Jianhua Huang, Haipeng Shen and John Aston will start to develop FDA tools for data from exponential family distributions, motivated by John Aston's talk on PET.
- Dan Yang, Haipeng Shen, Dong Wang, and Hongtu Zhu will work on developing FDA methods that incorporate general spatial and temporal dependence, motivated by NDA applications.
- Jianhua Huang and Dan Shen are motivated by multimodal analysis to develop CCA/LDA type of methods.
- Yong Fan and Jieping Ye have started to integrate regularization methods with imaging registration methods together.

5. Diversity

Gender: The SAMSI NDA program has included three female scientists in the organizing committee, four female scientists in the oral presentation, and over 25 female scientists as participants in both weeks. For instance, Prof. Jane-Ling Wang as a female statistician is the co-chair of NDA.

Ethnic: The SAMSI NDA program did not collect ethnic information. During the screening process, we made our decision purely based on applicants' interest. Dr. Simpson Sean as an Africa American was a participant of Week 2 and organized a working group.

Institution: Most participants come from big public research universities, such as UNC, UCSU, UGA, UT Dallas, UC Davis, Michigan, Texas A&M, FSU, Houston U, UVa, U Wisconsin-Madison, ASU, UC Irvine, Ohio State University, East Carolina U, and UC Berkeley. Small amount of participants came from Princeton, JHU, Columbia, NYU, and CMU. A few participants came from foreign countries including China, UK, German, and Australia.