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Structural MRI Analysis

Charles DeCarli, MD, FAAN
Evan Fletcher, PhD
Noel Smith, PhD
Baljeet Singh, BS

UCDAVIS
ALZHEIMER'S DISEASE CENTER

IDeA Lab
Imaging of Dementia and Aging

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Outline

1) MRI data collection
2) Image pre-processing at NACC
3) UCD Analysis Pipeline
4) Summary of processed MRI data

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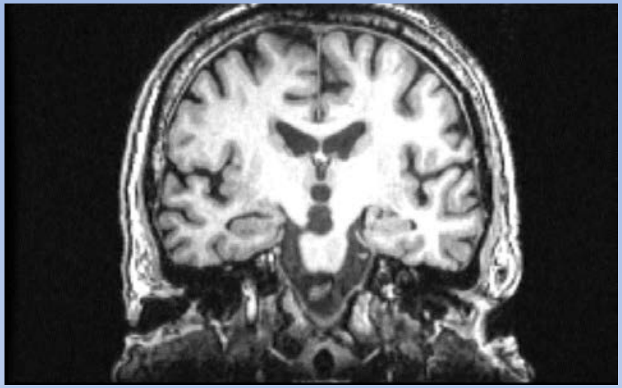
RESEARCH STRUCTURAL MRI

Data collection



- Subject population
  - – UDS subjects
  - – 2005 – present
- IRB sharing approval and consent
- Upload Process
  - Batch Upload (sFTP)
  - Direct upload through NACC MRI Data Submission System

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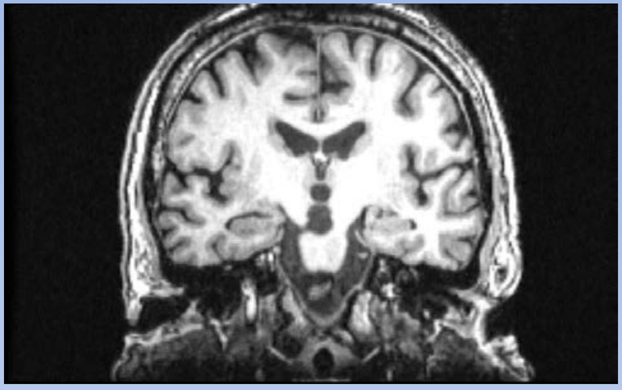
Data collection



- Scan types
  - 3D T1-weighted (e.g., MPRAGE, FSPGR)
  - FLAIR (e.g., turbo, fast, TSE)
  - DTI (e.g., 2.5mm/1300b/40dir, applicable gradient table)
  - T2
  - Additional scan types (e.g. resting state fMRI)
- DICOM de-identification
  - Patient ID→NACCID
  - Institution name→NACCADC
  - Identifiable tags stripped
  - Machine Meta data retained

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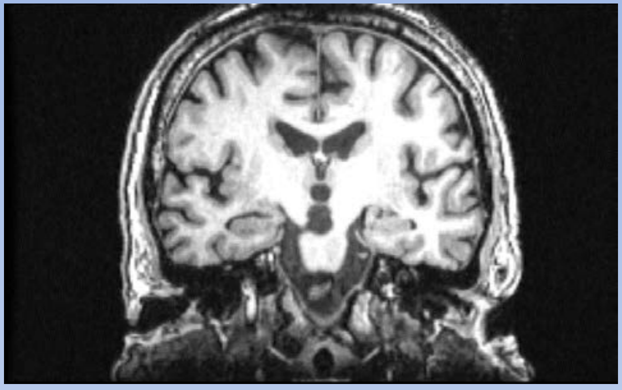
Data Archive



- Hierarchical Data Structure
- Standardized Image Naming Convention
- Standardized pipeline methodology
- Imaging summary database
- Reproducible Science approach
    - Tracking/dating of all processing
- Easy Data Sharing

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Analysis Methods

- Multi-atlas skull strip
- Empirical Bayesian image segmentation into gray/white/CSF on T1 weighted images
- Multi-atlas hippocampal segmentation with label refinement
- Empirical Bayesian segmentation of T1 and FLAIR for white matter hyperintensities

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Summary Variables

- Supratentorial Intracranial volume
- Gray/White/CSF volumes
  - Cortical
  - Regional (lobar, DKT atlas)
- White matter hyperintensity volume
- Hippocampal volume
- Cortical Thickness

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Subject Demographics (n=4616)

- Diagnoses
  - NL: 1978 (43%)
  - Impaired Not MCI: 129 (3%)
  - MCI: 806 (17%)
  - Dementia: 1703 (37%)

Suspected etiology at the most recent UDS

Alzheimer's disease	1820	73%
Lewy body disease	149	6%
Vascular brain injury or stroke	137	5%
FTLD - with bvFTD	71	3%
FTLD - with PPA	41	2%
FTLD – Other	25	<1%
Traumatic brain injury	266	11%

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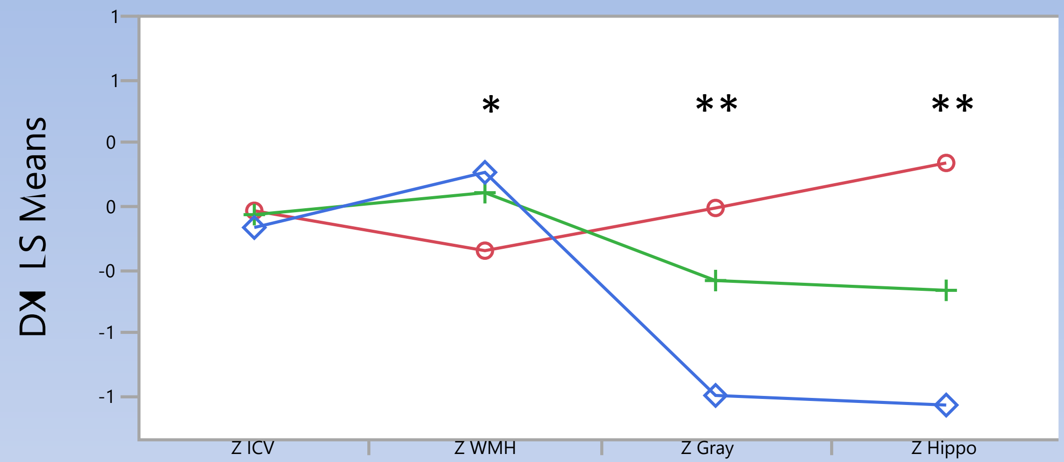
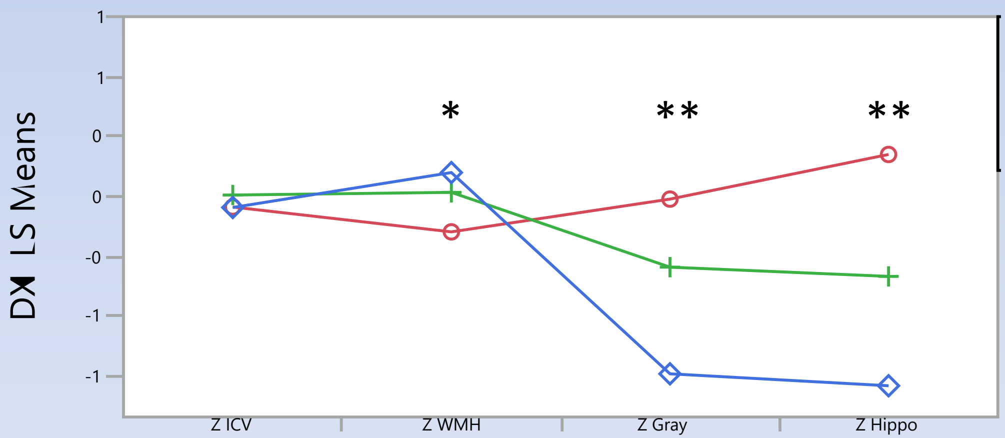
Regional Differences by Diagnosis

Unadjusted for MRI Machine information





NL

MCI

Demented

Tukey HSD
* Nl v Impaired
** All Differ

adjusted for MRI Machine information

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Example of Utilization of Summary Data

A Clinicopathological Investigation of White Matter Hyperintensities and Alzheimer's Disease Neuropathology

Michael L. Alosco, Ph.D.*,[a,b] Michael A. Sugarman, Ph.D.*,[a,c] Lilah M. Besser, Ph.D.,[d]
Yorghos Tripodis, Ph.D.,[a,e] Brett Martin, M.S.,[a,f] Joseph N. Palmisano, MPH, MA[a,f]
Neil W. Kowall, M.D. [a,b,g,h], Rhoda Au, Ph.D.,[b,l,j,k] Jesse Mez, M.S., M.D.,[a,b]
Charles DeCarli, M.D.,[l] Thor D. Stein, M.D., Ph.D.,[a,g,m,n] Ann C. McKee, M.D.,[a,b,g,m,n],
Ronald J. Killiany, Ph.D.,**[a,k,o] Robert A. Stern, PhD,**[a,b,k,p]

In press: Journal of Alzheimer's Disease

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WMH predicts ADNP

	Predicting ADNP: $R^2 = 0.40$; AUC = 0.84			
	B	Wald Z	p	OR (95 % CI)
Intercept	-13.05	-2.19	0.028	--
APOE ε4 carrier	3.39	3.75	< 0.001	29.57 (5.04-173.37)
Age at death	0.07	1.56	0.120	1.07 (0.98-1.16)
Total brain volume	0.01	2.12	0.034	1.01 (1.00-1.01)
WMH volume	0.04	2.09	0.037	1.04 (1.00-1.08)

OR = Odds ratio per unit increase in the predictor. Total brain and WMH volume was measured in cm^3.

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WMH Predicts CVD

	1. Atherosclerosis (n = 31)			2. Arteriolosclerosis (n = 39)			3. Amyloid angiopathy (n = 16)		
	B	p	OR (95% CI)	B	p	OR (95% CI)	B	p	OR (95% CI)
Intercept	-7.91	0.15	--	-13.46	0.01	--	-10.19	0.11	--
APOE ε4 carrier	0.30	0.58	1.35 (0.47-3.86)	1.51	0.009	4.54 (1.46-14.11)	1.25	0.07	3.49 (0.89-13.70)
Age at death	0.11	0.014	1.12 (1.02-1.22)	0.12	0.004	1.13 (1.04-1.23)	0.03	0.52	1.03 (0.94-1.13)
Total brain volume	-0.00	0.39	1.00 (0.99-1.00)	0.00	0.41	1.00 (1.00-1.01)	0.00	0.15	1.00 (1.00-1.01)
WMH volume	0.01	0.37	1.01 (0.99-1.03)	0.02	0.21	1.02 (0.99-1.05)	0.04	0.032	1.04 (1.00-1.08)
	4. Microinfarcts (n = 36)			5. Infarcts/lacunes (n = 26)					
	B	p	OR (95% CI)	B	p	OR (95% CI)			
Intercept	-7.91	0.12	--	-5.47	0.31	--			
APOE ε4 carrier	-0.11	0.84	0.90 (0.32-2.53)	-0.07	0.91	0.93 (0.29-2.95)			
Age at death	0.07	0.07	1.07 (0.99-1.15)	0.06	0.18	1.06 (0.98-1.15)			
Total brain volume	0.00	0.62	1.00 (1.00-1.01)	-0.00	0.71	1.00 (0.99-1.00)			
WMH volume	0.03	0.029	1.03 (1.00-1.06)	0.04	0.007	1.04 (1.01-1.08)			

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Summary

- NACC capable of DICOM receipt, storage, cleaning and sharing on sufficient scale
- IDeA capable of analysis on sufficient scale
- Preliminary results reveal
  - Significant Dx group differences accounting for vast differences in Field Strength and Machine Models
- Data being utilized for novel publications

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Conclusions

- Central storage and acquisition of MRI data leads to large amounts of reliable data that can be used in novel ways by AD Centers not experienced in image processing
- Usefulness of the data does not appear to be significantly compromised by differences in sequence acquisition, field strength or machine type when analyzed centrally
- Future, more sophisticated analyses may add to the richness of the dataset

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