ADNI-3 MRI Protocol

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Introduction

Brief History of ADNI:
The Alzheimer's Disease Neuroimaging Initiative (ADNI) is a longitudinal natural history study. Data from ADNI is publicly available (http://adni.loni.usc.edu). The third phase of ADNI (ADNI-3) began in late 2016, with subject imaging beginning in earnest in mid-2017.

MRI developments for ADNI-1 (2004-2009) focused on consistent longitudinal structural imaging on 1.5T scanners using T1- and T2-weighted sequences. One-fourth of ADNI-1 subjects were also scanned using essentially the same protocol on 3T scanners.

In ADNI-GO/ADNI-2 (2010-2016) imaging was performed at 3T with T1-weighted imaging parameters similar to ADNI-1. In place of the T2-weighted image from ADNI-1, 2D-FLAIR and T2*-weighted imaging was added at all sites. Fully sampled and accelerated T1-weighted images were acquired in each imaging session. Advanced imaging was included depending on scanner manufacturer: diffusion imaging on GE scanners, resting state functional MRI on Philips scanners and arterial spin labeling on Siemens scanners.

ADNI-3 imaging is being done exclusively on 3T scanners. Nearly all of the imaging sequences from ADNI-2 have been updated for inclusion in ADNI-3. Each of the ADNI-2 "advanced imaging" sequences is now included in all protocols with a few site-wise exceptions related to sequence license issues.

Scope of ADNI:
ADNI imaging is carried out at 57 imaging centers on subjects enrolled at 59 clinical sites. Two of the imaging centers each serve two enrolling sites. Scanners from the three largest MRI vendors (GE, Philips and Siemens) are supported across nearly all of the current software configurations. ADNI subjects are only a small part of the workflow at each imaging center so ADNI has no control over scanner system upgrades.

Product Sequence Considerations

Rationale:

ADNI is funded through a public/private partnership in order to establish multi-site imaging methods suitable for inclusion in drug studies as well to investigate Alzheimer's disease progression. **In order to create imaging protocols that can be used to support drug studies it is necessary to restrict the sequences employed to those commercially available on scanners.**

ADNI-3 Basic and Advanced

Rationale:

There is a broad gulf between older MRI systems and the state of the art production systems within each vendor's product line. The range of scanners being qualified for use in ADNI scanning as of late 2016 is given in the Scanner Table.

A two-tiered approach is taken to accommodate the range of variability in scanners. Thus, "ADNI-3 Basic" and "ADNI-3 Advanced" protocols have been created. An underlying assumption is that scanners will be upgraded replaced over the lifespan of ADNI-3 leading to increased use of the ADNI-3 Advanced protocols.

Structural T1-weighted, 3D FLAIR, T2* GRE, ASL, and high resolution images of the hippocampus are common across basic and advanced protocols within each vendor.

The Advanced Diffusion MRI and Resting State fMRI scans take advantage of simultaneous multislice acceleration for echo-planar images (EPI). For longitudinal consistency, they can be down-sampled post-scan to match the Basic sequences.

Scanner Table

- Running the Advanced protocol requires both hardware and software support.
- Hardware: a high channel count receiver array and high performance imaging gradients are taken as requisite to run the ADNI-3 Advanced protocol.
- Commonly, suitable hardware to run the ADNI-3 Advanced protocols has become available ahead of software support. This table speculates, based largely on hardware, which protocols may be in use circa 2018-2019.

Scanner Make and Model	No. in ADNI-3	Capable of Advanced	Comment
GE 750	9	Y	Contingent on high channel count receive coil with diffusion in software DV26; fMRI possibly in DV27 (no release date)
GE 750W	3	N	Wide bore gradient performance
Siemens Prisma/ PrismaFit	12	Y	32 or 64 channel receive array, SW VE11C and up. SMS license required
Siemens Skyra	5	?	Wide bore gradient performance (Can run advanced but will be slow)
Siemens Verio	6	N	Wide bore gradient performance
Siemens Trio/TIM	7	N	Out of production
Philips Achieva	6	?	Wide bore gradient performance (Can run advanced but will be slow)
Philips Ingenia 3T CX	2	Y	Software level 5.3 and up
Other/Undecided	7		

ADNI-3 Sequence Parameters

- Parameters of the ADNI-3 sequences given below are approximate. Parameters will vary based on system hardware and software.
- Unless otherwise stated the ADNI-3 Basic and Advanced protocols share the same parameters. For example the MP-RAGE is the same in both protocols while diffusion and fMRI differ.
- Choice of ASL sequence is driven almost entirely by sequence availability: 3D pCASL being preferred if available.
- ADNI-3 data and protocol information is maintained at http://adni.loni.usc.edu

Sequence Name	Geometry (FOV @ reconstructed resolution) in mm	Timing Parameters in ms	Approx. run time in minutes	Purpose	Notes
MP-RAGE	208x240x256mm @1x1x1mm	TE=min full echo TR=2300 TI=900	6:20	T1-weighted structure analysis; also may be used as source of spatial information in PET imaging	2X accelerated image acquisition
3D FLAIR	256x256x160mm @1.2x1x1mm	TE=119 TR=4800 TI=1650	5:30	White matter disease, infarction, pathology. May be used in conjunction with MP-RAGE for multi-spectral tissue segmentation	Sequence is sensitive to implementation details. TE definition varies by vendor, effective TE is quoted
High Res Hippo	175x60x175mm @0.39x2x0.39mm	TE=50 TR=8020	4:20	Hippocampal subfield measurement	Oblique acquisition with 2mm thick slices perpendicular to long axis of hippocampi
T2* GRE	220x220x176mm @0.85x0.85x4mm	TE=20 TR=650	4:10	Cerebral microbleed assessment	GRE as opposed to SWI because GRE is more universally available
ASL	240x240x160mm @1.9x1.9x4mm	TE=10.5 TR=4885 PLDelay=2000	4:00	Metabolism	3D pCASL implementation on GE (all) and Philips SW version 5.3 (planned); 3D-PASL on Siemens; 2D-PASL on Philips SW version <5.3
Diffusion	ADNI-3 Basic 232x232x160mm @2x2x2mm	TE=56 TR=7200	7:30	DTI	Single b=1000 s/mm^2 shell b=0 images interleaved throughout if possible in product sequence
	ADNI-3 Advanced 232x232x160mm @2x2x2mm	TE=71 TR=3300	7:10	Tractography + better tissue characterization than can be done with DTI	Three shells: b = 500,1000, 2000 s/mm^2 (112 total diffusion weighted directions)
EPI-BOLD (time chosen to be 10 wall clock minutes)	ADNI-3 Basic 220x220x163mm	TE~30 TR=3000 FA=90°	10:00	RSfMRI analysis	2X accelerated (even/odd interleave) P>>A phase encoding
	ADNI-3 Advanced 220x220x160mm @2.5x2.5x2.5	TE~30 TR=600ms FA=53°	10:00	RSfMRI analysis	64 slices of SMS=8 acquired, CAIPI-shift=4