

Neuroimage Experimental Data Base Resources

Maria Teresa García Sebastian

Grupo de Inteligencia Computacional, UPV/EHU

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1 Introduction

The goal of this report is to give an impression of the current status of the neuroscience databases of structural and functional techniques available through Internet, with an emphasis in Magnetic Resonance Imaging (MRI). Modern neuroimaging techniques such as structural (Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Diffusion Tensor Imaging (DTI)) or functional techniques (Positron emission tomography (PET), Single photon emission computed tomography (SPECT), Functional Magnetic Resonance Imaging (fMRI) and functional Diffusion Tensor Imaging (fDTI)) play an important role in the diagnosis of neurodegenerative diseases.

In recent years MRI has become one of the most popular techniques used in radiology to visualize the structure and function of the body, because it is a non-ionizing radiation medical imaging technique. It provides detailed images of the body in any plane and techniques based on the principles of MRI like fMRI, DTI or fDTI are being increasingly used in the preclinical study of certain neurodegenerative diseases.

The availability of public image databases for experimental purposes allows the validation of propositions of computational methods under a common experimental framework. They allow also to reproduce the results claimed by the research groups, both relative to diagnostic issues and to computational methods. In this regard, the simulated MRI images from the BrainWeb site [2], and the clinical images from the Internet Brain Segmentation Repository (IBSR) [7], which are provided with expert segmentations that can be used as the ground truth for validation processes, have been widely used as benchmarks for a number of algorithms devoted to segmentation, filtering and correction of artifacts in MRI, such as the Intensity Inhomogeneity (IIH). A number of new resources have been added in recent years, the fruit of public funded ongoing research projects, to those early public database efforts. During last years new projects have been developed individually by research groups as the Laboratory of Neuro Image (LONI) [8] or through collaborations with other groups, which are working in the same research area related to image analysis and the study of neurodegenerative diseases, building consortiums such as [1, 6]. Resulting from these projects there are many public resources (images, clinical data, demographics and results of the studies) that are available for validation and refutation purposes of both clinical conclusions and computational algorithms, keeping pace with the fast evolution of the imaging devices and techniques. In fact, the field is suffering such an explosive growth of public resources and an effervescence of results, techniques and publications that the present account may well be outdated in a very short time. The works of the PhD candidate have profited from some of these databases, namely the IBSR, BrainWeb and OASIS repositories.

2 IBSR

The Internet Brain Segmentation Repository (IBSR) [7] is a repository of magnetic resonance (MR) brain images and segmentation results. The IBSR was initially created in April 1996 and is maintained by Andrew Worth at the CMA. Currently there are six MR brain data sets, which were provided by the Center for Morphometric Analysis at Massachusetts General Hospital and are available at [7]. Most of them have T1-weighted MR images of healthy subjects. Two data sets have images of two different patients with brain tumors.

There are three different directories in which data sets can be found organized into “img”, “seg” and “otl” directories, which contain the raw, segmented and outlined images, respectively. However not all data sets have the “seg” and/or “otl” directories. Raw images are 256x256 of 16-bit, but some of them have also these images scaled to 8-bit. Segmented images are “trinary” images (pixels are labeled as a Grey Matter or White Matter tissue or as other), with the same dimensionality as the raw images. Outlined images are the result of semi-automated segmentation techniques performed by an expert and contain lists of points that define certain structures in each scan image. They are defined in a 512x512 grid, because they were created using oversampled images to double size. The difference with the segmentation directory is that the trinary files group all structures in to grey/white/other while the otl files list each neuroanatomical structure separately, so that the information provided by the segmentation trinary images is only a small subset of the information in outlined images. The data was intended to test MRI supervised and unsupervised segmentation algorithms.

2.1 Normal subject, 'Ideal' registered multi-echo brain scan

Data set 657 was created in 1996. It contains seven different image types of the same normal subject (conventional T1, PD and T2 Spin echo sequences; Fast T1, low signal/noise, SPGR (1 avg); Fast T1, better signal/noise, SPGR (2 avgs); Fast PD and T2 FSE sequence). Each of the volumes are registered scans of 18 slices (“img” format with no header information), 2.3 Mb (15.75 Mb total). Scans were acquired at the NMR Center of the Massachusetts General Hospital with a 1.5 tesla General Electric Signa. No segmentation information is provided.

2.2 Adult Male

Data set 788_6 was created in 1996. It contains T1-weighted MRI data with complete expert segmentations (trinary and outlines) from a 55 year old male subject. Each volume has been stored in 60 files that represent the slices through the brain, without header information. Scans were acquired with a 1.5 Tesla General Electric Signa. Contiguous 3.0 mm three-dimensional coronal T1-weighted spoiled gradient echo (SPGR) images of the entire brain was

attained with the following parameters: TR= 40 msec, TE= 5 msec, flip angle =40 degrees, field of view =24 cm, matrix =256x256, and averages =1.

Images were positionally normalized by imposing a standard three-dimensional brain coordinate system on each 3D MR scan [40, 23]. The repositioned scans are then resliced into normalized 3.0 mm coronal, 1.0 mm axial, and 1.0 mm sagittal scans which are used for subsequent analyses.

Gray-white matter segmentation (other=0; gray=128 and white=254) was performed with a semi-automated intensity contour mapping algorithm [29] and also using signal intensity histograms. Neuroanatomical regions of interest for gray/white segmentation include cortical grey matter, subcortical white matter, lateral, third and fourth ventricles, caudate, putamen, globus pallidus, hippocampus-amygdala complex, thalamus proper (including all thalamic nuclei except the lateral and medial geniculate bodies), ventral diencephalic complex (including hypo-, epi-, and subthalamus, substantia nigra, red nucleus medial and lateral geniculate bodies), brainstem, cerebellum cortex and cerebellar central mass, according to the anatomic definitions of [22], with one exception. The central gray nuclei was subdivided at the hypothalamic fissure into thalamus proper and ventral diencephalon.

2.3 5 year old child:

Data set 1320_2 was created in 1996. It contains T1-weighted MRI data with complete expert segmentations (trinary and outlines) from a 5 year old subject. Each volume has been stored in 128 files that represent the slices through the brain, without header information. The MRI scan was acquired with a 1.5 Tesla General Electric Signa. Contiguous 1.5 mm three-dimensional coronal T1-weighted spoiled gradient echo (SPGR) images of the entire brain was attained with the following parameters: TR = 40 msec, TE = 5 msec, flip angle = 40 degrees, field of view = 24cm, matrix = 256x256, and averages = 1.

Images were positionally normalized by imposing a standard three-dimensional brain coordinate system on each 3D MR scan [40, 23]. The repositioned scans are then resliced into normalized 1.5 mm coronal, 0.9375 mm axial, and 0.9375 mm sagittal scans which are used for subsequent analyses.

Gray-white matter segmentation (other=0; gray=128 and white=254) was performed following the procedure described in section 2.2.

2.4 20 Normal Subjects

Data set 20_Normal was created in 1997. It contains T1-weighted MR images, from 20 normal subjects, of 3.1mm slice thickness (16-bit data; 8-bit scaled 3D data and 8-bit scaled 3D data (brain regions only)) and expert segmentations (other=0; csf=128; gray=192; white=254). Volumes of 16-bit have been stored in 60 “.img” files that represent the slices through the brain. On the other hand 8-bit and segmented images have been stored in data files (.buchar) and header files (.hdr), where header files have four ascii numbers that give the size of the data set. The segmented and 8-bit images have less slices than the 16-bit image

data. The matching segmentation must be done using the offsets given at [7] for this data set.

Images are coronal three-dimensional T1-weighted spoiled gradient echo MRI scans, that were obtained on two different imaging systems. Ten FLASH scans performed on a 1.5 tesla Siemens Magnetom MR System (Iselin, NJ) with the following parameters: TR = 40 msec, TE = 8 msec, flip angle = 50 degrees, field of view = 30 cm, slice thickness = contiguous 3.1 mm, matrix = 256x256, and averages = 1. Ten 3D-CAPRY scans performed on a 1.5 tesla General Electric Signa MR System (Milwaukee, WI), with the following parameters: TR = 50 msec, TE = 9 msec, flip angle = 50 degrees, field of view = 24 cm, slice thickness = contiguous 3.0mm, matrix = 256x256, and averages = 1.

Images were positionally normalized by imposing a standard three-dimensional brain coordinate system on each 3D MR scan [40, 23]. The repositioned scans are then resliced into normalized 3.0 mm coronal, 1.0 mm axial, and 1.0 mm sagittal scans which are used for subsequent analyses.

Segmentation was performed on the positionally normalized scan by trained investigators using a semi-automated intensity contour mapping algorithm [29] and also using signal intensity histograms. Other neuroanatomical structures were segmented similarly [22].

Segmentation Performance Index

IBSR facilitates segmentation comparisons of six classification methods tested over this collection of images, provided by Jagath C. Rajapakse and SPM5 GM segmentation done by On Tsang. Results from Rajapakse are partially based on the method described in [36], where the comparison metric is the average overlap also called Tanimoto coefficient [21], eq. 1:

$$T = \frac{|A \cap B|}{|A \cup B|}, \quad (1)$$

where A and B are sets of voxels corresponding to different segmentations.

2.5 Tumor patients: various scans over time

Subject 126

This data set was created in 1999. It contains multiple scans of a 59 year old female with a tumor, taken at roughly 6 month intervals over three and a half years. The T1 + Gadolinium MRI scans were acquired with a 1.5 Tesla General Electric Signa and different parameters.

Subject 536

This data set was created in 1999. It contains multiple scans of a patient with a tumor (images and outlines), taken at roughly 6 month intervals over three and a half years. Each series has been stored in 60 .img files with no header information. The pixel resolutions on these are 0.9375 x 0.9375 mm in-plane

by 3.1 mm slice thickness. The outline files include 4 outlines: a contralateral reference region (the cerebral hemisphere of the right (unaffected) hemisphere), and three outlines of the enhancing tumor based upon intensity countours 1, 2 and 3 standard deviations above the mean of the contralateral reference region.

Images were registered using the CMA's standard positional normalization coordinate system.

2.6 IBSR V2.0

This data set was created in 2003 and 2004 and currently contains T1-weighted MR Image data from eighteen subjects, with expert segmentations of 43 individual structures (1.5mm slice thickness). Data are in CMA and analyze formats. For each subject there is T1-weighted volumetric images that have been 'positionally normalized' into the Talairach orientation (rotation only) and also have been processed by the CMA 'autoseg' biasfield correction routines.

Gray-white matter segmentation include segmentation of the 3rd Ventricle, 4th Ventricle, Brain Stem, and Left and Right: Accumbens area , Amygdala, Amygdala Anterior, Caudate, Cerebellum Cortex, Cerebellum Exterior, Cerebellum White Matter, Cerebral Cortex, Cerebral Exterior, Cerebral White Matter, Hippocampus, Inf Lat Vent, Lateral Ventricle, Pallidum, Putamen, Thalamus Proper, VentralDC, and vessel.

3 BrainWeb: Simulated Brain Database

This simulated brain database (SBD) [2] was provided by McConnell Brain Imaging Centre at the Montréal Neurological Institute [15], McGill University. It contains a set of realistic Magnetic Resonance Imaging (MRI) data volumes produced by an MRI simulator [18, 30, 38]. Currently contains simulated brain MRI data based on two types anatomical models [19] ("phantoms"): normal and multiple sclerosis (MS), which can serve as the ground truth for any analysis procedure. These anatomical models consist of a set of 3-dimensional "fuzzy" tissue membership volumes, one for each tissue class. The voxel values in these volumes reflects the proportion of tissue present in that voxel, in the range [0, 1]. The volumes are defined at a 1mm isotropic voxel grid in Talairach space, with dimensions 181x217x181 (XxYxZ) and origin coordinates -90,-126,-72 (x,y,z) in Talairach space.

In addition to the fuzzy tissue membership volumes, a discrete anatomical model is provided which consists of a class label (integer) at each voxel, representing the tissue which contributes the most to that voxel.

Volumes can be downloaded in MINC or raw format.

3.1 Normal Brain Volumes

Pre-computed simulated SBD

In the pre-computed SBD data are available for viewing in three orthogonal views (transversal, sagittal, and coronal) and for downloading with the parameter settings fixed to 3 modalities, 5 slice thicknesses, 6 levels of noise, and 3 levels of intensity non-uniformity. These simulations are based on an anatomical model of normal brain, which is available at a resolution of 1mm^3 and also for thicker slices (in Z direction): 3mm, 5mm, 7mm and 9mm. Tissue classes available for this phantom are: Background, CSF, Grey Matter, White Matter, Fat, Muscle/Skin, Skin, Skull, Glial Matter and Connective.

Custom MRI simulations interface

Through the BrainWeb custom MRI simulations interface it is possible to choose arbitrary parameters and obtain different volumes based on the same normal anatomical model as in subsection 3.1.

20 sets of simulated data with specific parameters

Currently, it is only possible to download 20 different sets of T1-weighted simulated data, based on 20 anatomical models of 20 normal brains, with these specific parameters: SFLAH (spoiled FLASH) sequence with $\text{TR}=22\text{ms}$, $\text{TE}=9.2\text{ms}$, flip angle= 30 deg and 1mm isotropic voxel size. Tissue classes available for these phantoms are: Background, CSF, Grey Matter, White Matter, Fat, Muscle/Skin, Skull, Blood vessels, Connective (region around fat), Dura Matter and Bone Marrow.

3.2 MS Lesion Brain Volumes

Pre-computed simulated SBD

In the pre-computed SBD data are available for viewing in three orthogonal views (transversal, sagittal, and coronal) and for downloading with the parameter settings fixed to 3 modalities, 5 slice thicknesses, 6 levels of noise, and 3 levels of intensity non-uniformity. These simulations are based on an anatomical model of a human brain with “moderate” MS lesions, which is available at a resolution of 1mm^3 . Tissue classes available for this phantom are: Background, CSF, Grey Matter, White Matter, Fat, Muscle/Skin, Skin, Skull, Glial Matter, Connective and MS lesion.

Custom MRI simulations interface

Through the BrainWeb custom MRI simulations interface it is possible to choose arbitrary parameters and obtain different volumes based on three different MS anatomical models with “moderate” (the same anatomical model as subsection 3.2), “mild” and “severe” MS lesions.

4 OASIS

The Open Access Series of Imaging Studies (OASIS) [32] provides brain imaging data that are freely available for distribution and data analysis [12]. It is made available by Dr. Randy Buckner at the Howard Hughes Medical Institute (HHMI) at Harvard University, the Neuroinformatics Research Group (NRG) at Washington University School of Medicine, and the Biomedical Informatics Research Network (BIRN). Currently available data set consists of a cross-sectional collection of 416 subjects covering the adult life span aged 18 to 96 including 100 individuals over the age of 60, who have been diagnosed with early-stage Alzheimer’s Disease (AD).

For each subject 3-4 T1-weighted magnetization prepared rapid gradient-echo (MP-RAGE) MRI scans were acquired on a 1.5-T Vision scanner (Siemens, Erlangen, Germany), corresponding to multiple repetitions of the same structural protocol within a single session; a motion-corrected coregistered average of all available data; a gain-field corrected atlas-registered image to a standard space [40, 17]; and a masked version of the atlas-registered image, a grey/white/CSF segmented image [41]. Additionally, for 20 of the nondemented subjects, images from a subsequent scan session are also included as a means of assessing acquisition reliability. All images are in 16-bit big-endian Analyze 7.5 format.

This data set has been based on the following publications for demographic [37] (gender, handedness, age, education and socioeconomic status), clinical assessments [35, 37] (Mini-Mental State Examination (MMSE) and Clinical Dementia Rating (CDR)), and derived anatomic measures [17, 24] (total intracranial volume (eTIV), atlas scaling factor (ASF) and normalized whole brain volume (nWBV)).

The database has a complex structure, shown in figure 1. It contains, besides the raw MRI scans, the anatomic information, the registered images, the segmented and skull stripped images. Therefore, the database can be used to test several algorithms at different points in the processing pipeline. Figure 2 contains a table with the name codification and corresponding image types. Finally, figure 3 contains a summary of the database demographic information.

5 MORPHDTI_P0001

This data set contains high SNR DTI data and the co-registered DTI data for a healthy male volunteer scanned on three separate scanning sessions over 2 days [28, 31]. Fifteen DTI scans were performed in each scan session, producing 45 DTI datasets in total. Data was acquired on a 1.5T Philips MR unit at the F.M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Johns Hopkins University.

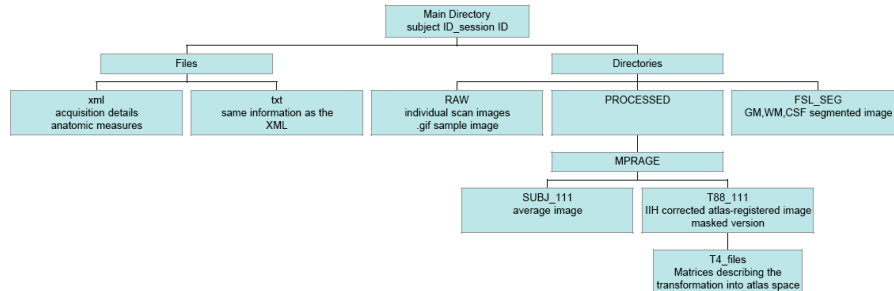


Fig. 1: File structure of OASIS Database

Name	Description	Dimensions	Vox. size	Orient
OAS1_xxxx_MRy_mpr-z_anon	Individual scan (z=repetition)	256x256x128	1x1x1.25	Sag
OAS1_xxxx_MRy_mpr_ni_anon_sbj_111	Image averaged across scans (i=# of scans)	256x256x160	1x1x1	Sag
OAS1_xxxx_MRy_mpr_ni_anon_111_t88_gfc	Gain-field corrected atlas registered average	176x208x176	1x1x1	Trans
OAS1_xxxx_MRy_mpr_ni_anon_111_t88_masked_gfc	Brain-masked version of atlas registered image	176x208x176	1x1x1	Trans
OAS1_xxxx_MRy_mpr_ni_anon_111_t88_masked_gfc_fseg	Brain tissue segmentation	176x208x176	1x1x1	Trans

Fig. 2: Types of Images included in the dataset

Age Group	N	Non-Demented				Demented				CDR 0.5/1/2
		n	mean	male	female	n	mean	male	female	
<20	19	19	18.53	10	9	0		0	0	0/0/0
20s	119	119	22.82	51	68	0		0	0	0/0/0
30s	16	16	33.38	11	5	0		0	0	0/0/0
40s	31	31	45.58	10	21	0		0	0	0/0/0
50s	33	33	54.36	11	22	0		0	0	0/0/0
60s	40	25	64.88	7	18	15	66.13	6	9	12/3/0
70	83	35	73.37	10	25	48	74.42	20	28	32/15/1
80s	62	30	84.07	8	22	32	82.88	13	19	22/9/1
≥90	13	8	91.00	1	7	5	92.00	2	3	4/1/0
Total	416	316		119	197	100		41	59	70/28/2

Fig. 3: Demographic summary

6 MIRIAD

Multisite Imaging Research In the Analysis of Depression (MIRIAD) data set [9, 5] has dual-echo MRI scans (currently 100 subjects) acquired at Duke University, which have been anonymized and uploaded by the Neuropsychiatric Imaging Research Laboratory (NIRL) [10] to the Biomedical Informatics Research Network/Storage Resource Broker (BIRN/SRB) [1] where they are accessed at BWH (Surgical Planning Laboratory, SPL) [13] and UCLA (LONI) [8].

At the Laboratory of Neuro Imaging (LONI) a study-specific atlas is constructed from the MRI scans with both PD and T2 contrasts. Subjects' scans are linearly aligned to the study space to acquire spatial normalization factors, and a BWH tissue and structure probability field atlas is non-linearly aligned to each individual subject. Dual-echo scans are segmented utilizing the individual subject-aligned tissue probability atlases at the Surgical Planning Laboratory, SPL; regions of interest and cerebral tissues are classified by an expectation maximization algorithm.

LONI completes the scan processing with a measurement of lobar volumes via a non-linear registration of study-specific lobar atlas to native subject spaces, and regional and lobar tissue volumes are computed. The image processing results, both the images and volumetric measurements, are uploaded to the SRB. Initial statistical analyses were performed at Duke, as the associated metadata (e.g., age, sex, diagnosis, clinical scales) resided there at the beginning of the project.

7 ELUDE

The Efficient Longitudinal Upload of Depression in the Elderly (ELUDE) data set is an anonymized collection of a longitudinal study of late-life depression at Duke University. There are 281 depressed subjects and 154 controls included. An MR scan of each subject was obtained every 2 years for up to 8 years (total of 1093 scans). Clinical assessments occurred more frequently and consists of a battery of psychiatric tests including several depression-specific tests such as the HAM-D, CESD, and MADRS.

8 Alzheimer's CATX

This Data set [14] contains activation maps of 9 Alzheimer's disease patients & 9 elderly controls [39]. It was provided by Andrew Saykin, Dartmouth Medical School and the last updated was in May 10, 2004. The task is about semantic processing: category exemplar (CATX)-identify word pairs with correct category exemplar relationships from among incorrect ones.

9 Realistic MRI data set

This Data set [14] contains realistic brain lesion distributions generated using a lesion-deficit simulator with spatial statistical model conforming to the Frontal Lobe Injury in Childhood Study [33, 27].

10 DTMRI Data

This is a DTI data set [3] acquired under Human Brain Project and National Research Resource Center grant. It contains raw and processed DTI data of 15 normal population, white matter atlases, DTI software. Currently the database has 2.5 mm isotropic resolution images and 2.2 mm isotropic resolution images. Only 2.5 mm data are available.

11 BIRN (Biomedical Informatics Research Network)

The Biomedical Informatics Research Network (BIRN) [1] was launched in 2001 with the goal of fostering large-scale collaborations in biomedical science by utilizing emerging cyberinfrastructure. An essential feature of the project is the collaboration of computer scientists and biomedical researchers from different research disciplines to design and implement a distributed architecture of shared resources usable by all biomedical researchers in order to advance the diagnosis and treatment of disease.

FBIRN_Traveling_Subject2003

This dataset includes five healthy subjects imaged twice at each of ten FBIRN MRI scanners on successive days. Functional and structural imaging, behavioral, and demographic data are available from 100 scanning sessions on these subjects.

BrainScape_BS002

This dataset includes seventeen healthy subjects with four resting state fixation scans plus one T1 scan and one T2 scan. The data were collected as part of a study on the behavioral effects of spontaneous BOLD fluctuations [26].

BrainScape_BS003

This dataset includes ten healthy subjects scanned 3 times with 3 conditions: eyes open, eyes closed, and fixating in addition to two anatomical scans (T1 and T2) [25].

fBIRN PhaseII

The Phase II multi-site clinical imaging study consists of approximately 250 subjects, both chronic schizophrenics and age- and gender- matched controls. The MRI data include structural and fMRI images from two separate scanning visits for each subject, including the Sternberg Item Recognition Paradigm and the Auditory Oddball paradigm, a breath hold task, and a sensorimotor task. The clinical assessments include behavioral measures, handedness and demographic measures, SES, smoking measurements, North American Adult Reading Test (NARRT), and clinical severity assessments for the clinical subjects. Currently data from three sites are released to the general research community; the remainder are awaiting IRB approvals for public data sharing.

12 ADNI (Alzheimer's Disease Neuroimaging Initiative)

The ADNI was launched in 2003 by the National Institute on Aging (NIA), the National Institute of Biomedical Imaging and Bioengineering (NIBIB), the Food and Drug Administration (FDA), private pharmaceutical companies and non-profit organizations, as a \$60 million, 5-year public-private partnership.

The primary goal of ADNI has been to test whether serial magnetic resonance imaging (MRI), positron emission tomography (PET), other biological markers, and clinical and neuropsychological assessment can be combined to measure the progression of mild cognitive impairment (MCI) and early Alzheimer's disease (AD). Currently there are available more than 32,000 MR and PET scans.

The initial goal of ADNI was to recruit 800 adults, ages 55 to 90, to participate in the research, approximately 200 cognitively normal older individuals to be followed for 3 years, 400 people with MCI to be followed for 3 years, and 200 people with early AD to be followed for 2 years.

13 Functional Brain Imaging of Young, Nondemented, and Demented Older Adults

This fMRI data set is available on Internet [4] since the year 2000. A paradigm involving repeated presentation of sensory-motor response trails was administered to 41 participants (14 young adults (18-24), 14 nondemented older adults (66-89) and 13 demented older adults (68-83)) [16].

All subjects were right-handed, english speakers, with normal (corrected) visual acuity. A history of neurological or visual illness served as exclusion criteria for all potential subjects. Furthermore, older adults were excluded if they had neurologic, psychiatric or mental illness which could cause dementia. Dementia status was determined using recruitment and assessment procedures developed by the Alzheimer's Disease Research Center at Washington University. Clinico-pathology studies in cognitively healthy aging and Alzheimer's disease; Relation of histologic markers to dementia severity, age, sex, and APOE genotype; CDR.

Stimulus display was controlled by a Power Macintosh computer (Apple, Cupertino, CA) using PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). Keypress responses were recorded using a fiber-optic light-sensitive keypress connected to a PsyScope button box (Carnegie Mellon University, Pittsburgh, PA). All buttons except one were physically covered to minimize response complexity.

Stimuli were rear projected (Am-Pro Model LCD-150, Ampro, Melbourne, FL) onto a screen placed at the back of the magnet bore. Participants viewed the screen through a mirror fastened to the top of the head coil. Participants requiring corrective lenses (mostly older adults) were supplied magnetcompatible glasses.

The basic task paradigm consisted of presentation of a 1.5-sec duration visual stimulus. Participants pressed a key with their right index fingers upon stimulus onset. The visual stimulus was an 8-Hz counterphase flickering (black to white) checkerboard subtending approximately 12° of visual angle (6° in each visual field). Stimulus parameters were identical to those used by [34]. The stimulus onset was triggered at the beginning of the image acquisition via the PsyScope button box. Spatial frequency of the checkerboard decreased with visual angle to be approximately constant in relation to acuity across the visual field. Runs were structured such that for every eight-image acquisition (21.44 sec), one of two kinds of trial condition were presented (15 trials per run for a total of 60 trials per subject).

Task trials either involved stimuli presented in isolation (one-trial condition) or in pairs with an inter-trial interval of 5.36 sec (two-trial condition). One-trial and two-trial conditions were pseudorandomly intermixed such that eight trials of one type and seven of the other appeared in each run. The logic of this design [20] is that the onetrial conditions can be examined to determine the evoked hemodynamic response to an isolated, transient event. The two-trial conditions further allowed the summation properties of the hemodynamic response to be examined: To the degree that the added responses in the two-trial conditions were similar to the responses in the one-trial conditions, the hemodynamic dynamic response exhibits linear summation. Four image acquisitions involving only fixation were acquired prior to the first trial and following the last trial in each run.

14 Neuroscience Database Gateway (NDG)

The Neuroscience Database Gateway (NDG) [11] began in 2004 as a pilot project developed by the Society's Brain Information Group (BIG). The NDG is now overseen by the Society's Neuroinformatics Committee and is hosted at Yale University (by Gordon Shepherd and Luis Marenco). The SfN Neuroscience Database Gateway provides links to five main types of database: Databases of experimental data; knowledge bases; software tools for neuroscience; bioinformatics resources; providers of research materials; all neuroscience databases.

15 LONI Image Data Archive (IDA)

The LONI Image Data Archive (IDA) [8] is a user-friendly environment for archiving, searching, sharing, tracking and disseminating neuroimaging and related clinical data. The IDA is utilized for dozens of neuroimaging research projects across North America and Europe and accommodates MRI, PET, MRA, DTI and other imaging modalities. A flexible data de-identification engine and encrypted file transmission help ensure compliance with patient-privacy regulations.

16 mBIRN Data Repository (mBDR)

The mBIRN Data Repository (mBDR) [9] is a public resource presented by the Morphometry testbed of the Biomedical Informatics Research Network (BIRN). It includes a range of raw and post-processed MRI images, related derived measures, and related subject measures. The data are organized by project OASIS, morphDTI_p0001, MIRIAD, ELUDE

17 fMRI Data Center (fMRIDC)

The fMRIDC is a public repository [4] of peer-reviewed fMRI publications projects and their underlying data. Currently there are 122 data sets available.

18 DEnLab Data Repository

The repository [14] contains both medical data such as the ones referred in sections 8 and 9, as well as some information about methods and computational techniques for medical image processing.

19 ICBM Human Atlases

The LONI Atlas site [8] consists of a collection of data, online viewers, images and animations that describe the various atlases (e.g. Alzheimer's Disease Template) developed at LONI. A complete description and discussion of these atlas requires a dedicated chapter.

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