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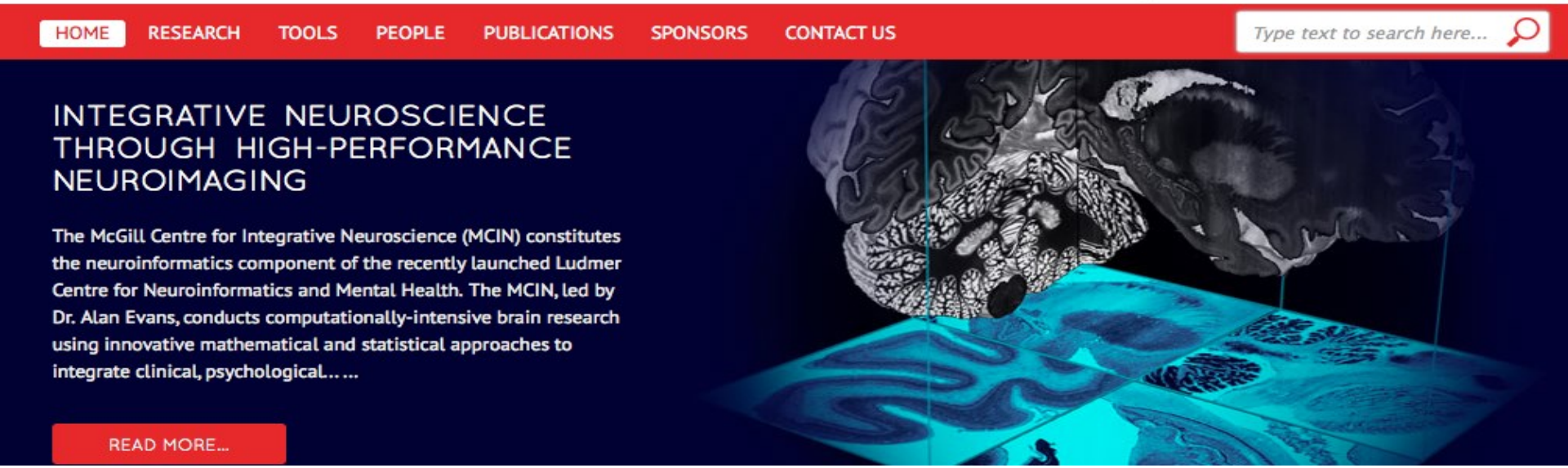


Major unresolved questions in brain imaging across the lifespan

Alan C. Evans, PhD
Montreal Neurological Institute/McGill University

Development of Brain Image Banks and
Age-Specific Normative Human Brain Atlases
Edinburgh, U.K.
August 28st, 2014

Discussion points

Minimum image and metadata needed to define normality?

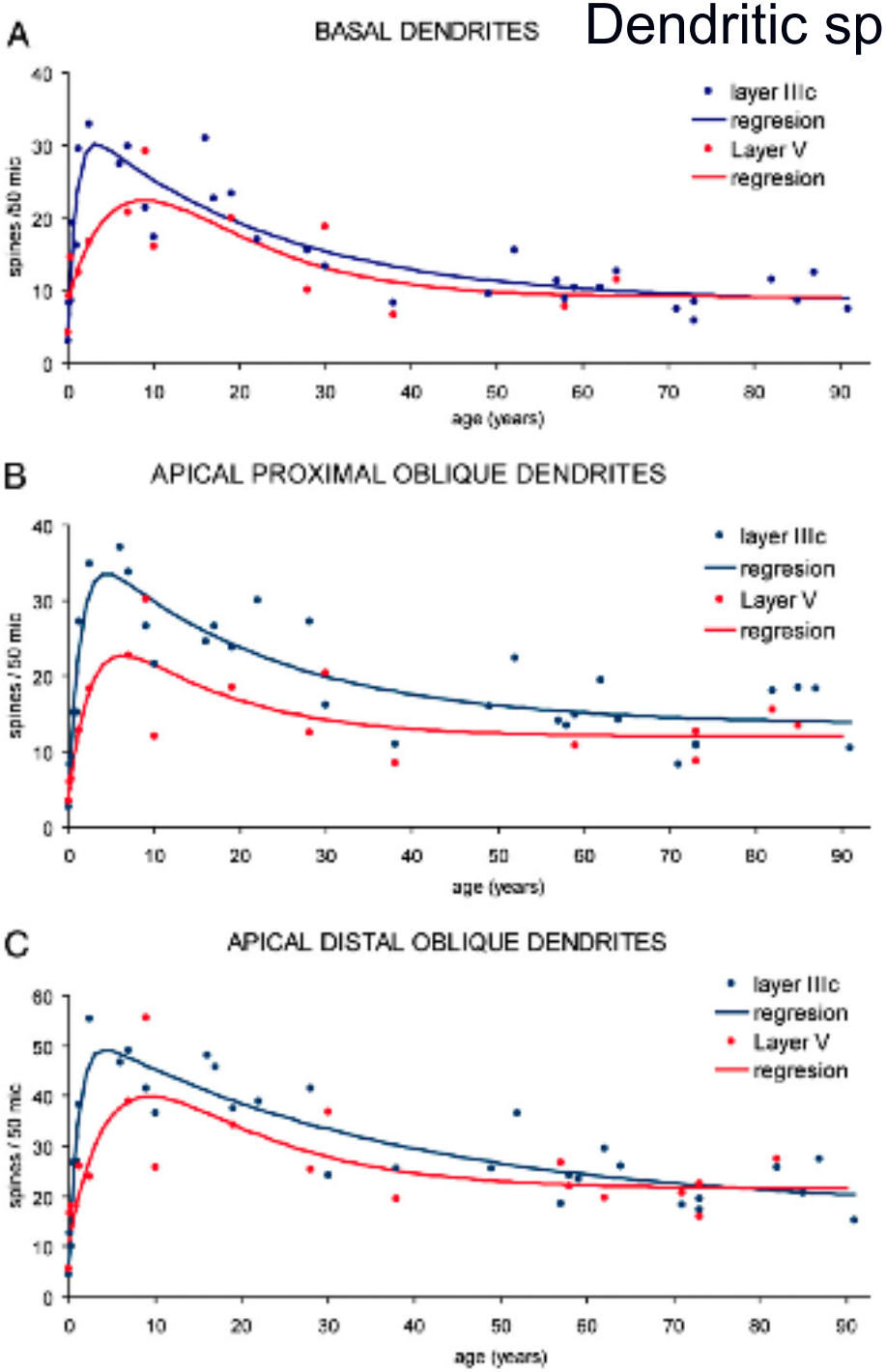
What can be done with existing data re. normality across lifespan ?

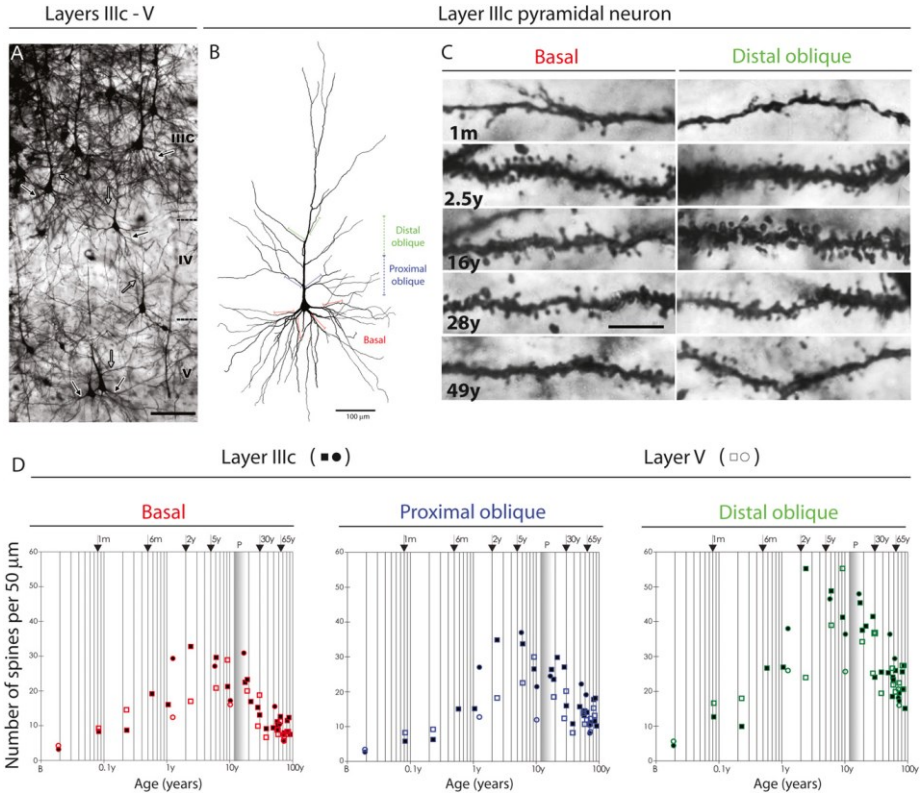
What are the likely gaps ?

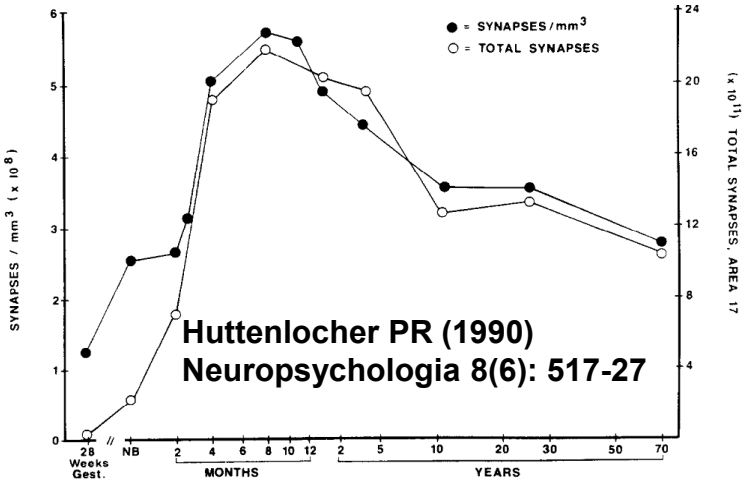
Is it realistic to combine image data from all stages of life ?

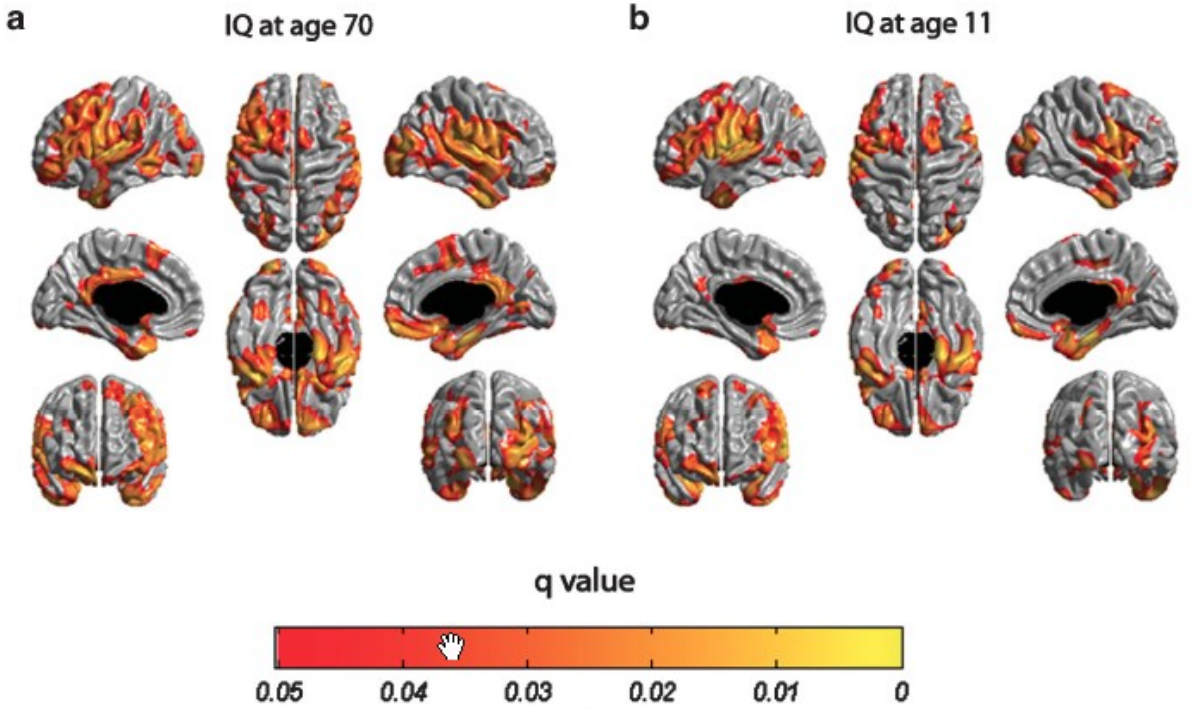
Dendritic spine density vs age (prefrontal cortex)

Petanjek et al. (2011) PNAS 108 (32): 13281–6





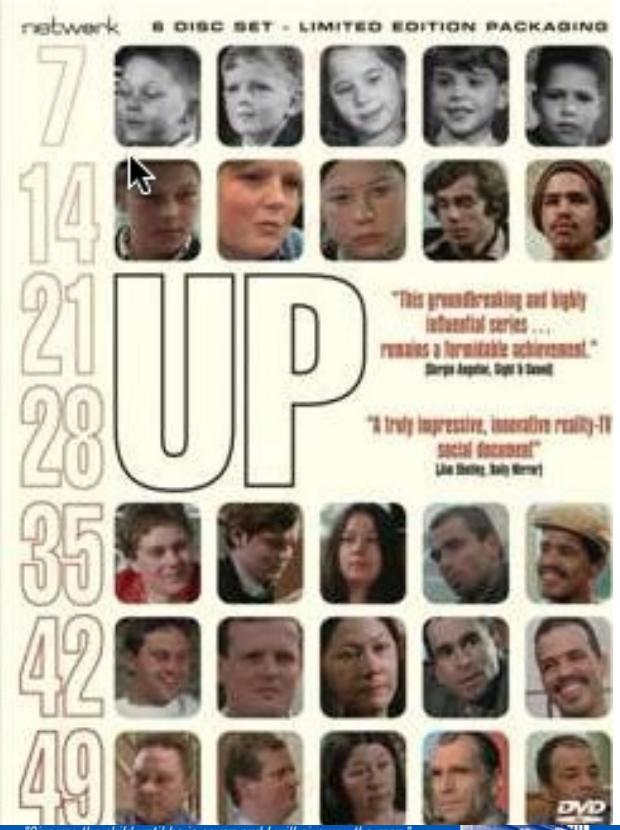


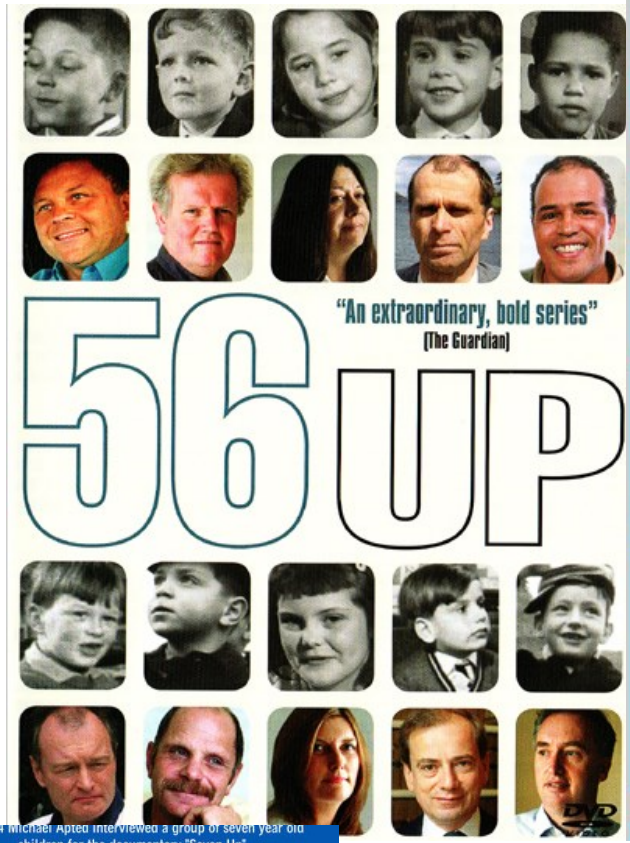


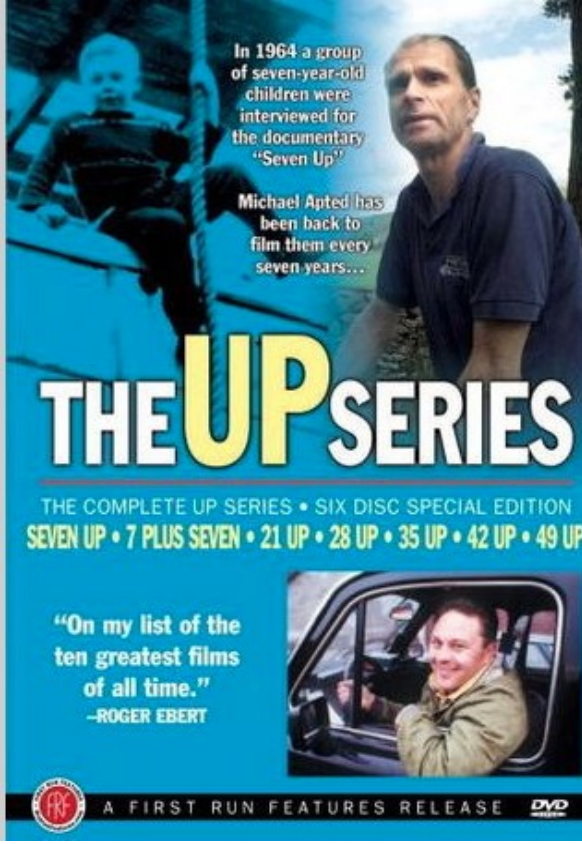
Childhood IQ accounts for two-thirds of association between IQ at 70 and cortical thickness at 73

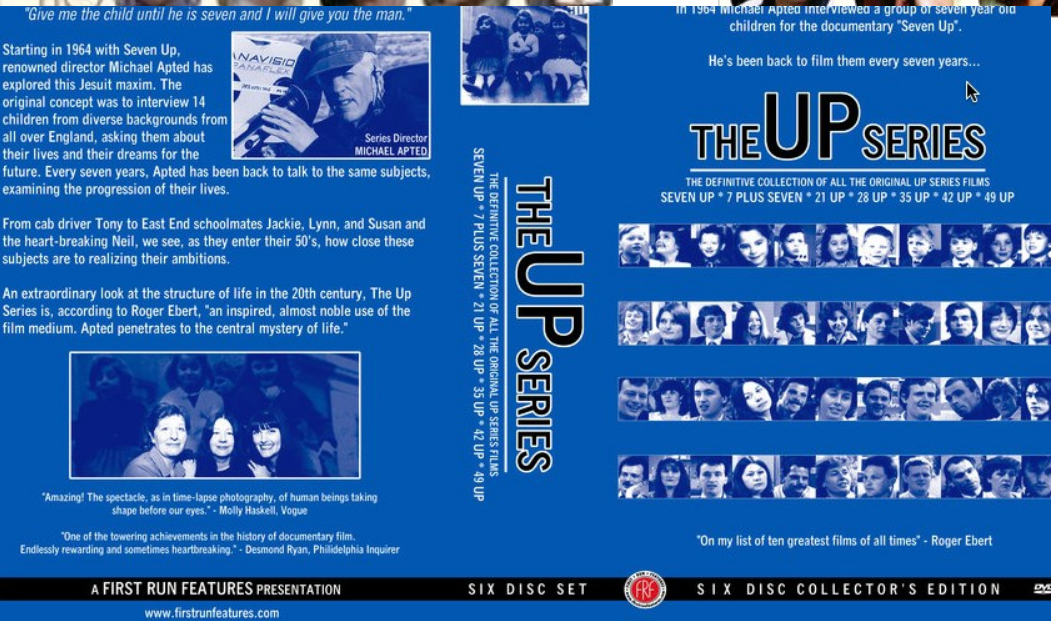
Karama S,…,Wardlaw J, Deary I (2014) Mol Psych 19:555-9

ADNI
Alzheimer's Disease Neuroimaging Initiative
Home > ADNI Science Home > About ADNI
NIH
NDAR National Database for Autism Research
Serving the autism research community
IBIS
ABIDE
Autism Brain Imaging Data Exchange
HUMAN Connectome PROJECT
ICBM
The MRI study of normal brain development
Sponsored by The National Institutes of Health
PARKINSON'S PROGRESSION MARKERS INITIATIVE
Play a Part in Parkinson's Research
imagen
indi
International Neuroimaging Data-Sharing Initiative
FUNCTIONAL CONNECTOMES PROJECT
OASIS
Human Brain Project









We need a decades-long longitudinal study

Challenges to multi-site studies

Acquisition
Different scanner manufacturers
Different field strengths
Different protocol parameters
Different acquisition procedures

Analysis
Slice registration/normalization
Intensity non-uniformity
Geometric distortion

Political ("herding cats")
Different MRI research cultures
Different psychology research cultures (clinical/experimental)
Competition for data access/publication
Communication problems (conference calls, e-mail poisoning)
Subject confidentiality
Different IRB regulations
Bureaucracy (government, university, corporate)

Unresolved questions in brain imaging across lifespan

- X-sectional (large N, multisite) vs. longitudinal (true 4D, impractical)
- Image (3D, longitudinal) vs Post-mortem (res/specificity, x-sectional)

- Acquisition protocol incompatibilities among contributing datasets
- Prospective acquisition protocol (coil, pulse sequence, field strength)
- Scanner stability across time (hardware/software upgrade, drift)
- Temporal changes in tissue contrast differ across pulse sequences
- Evolutionary changes in pulse sequence (e.g. DTI vs. HARDI)
- Compatibility: Raw data vs Derived data

- Demographic representation (age, gender, ethnicity, SES)
- Definition of “normal” (neurological, psychiatric, behavioural)
- Regulatory issues: IRB,confidentiality, ethics, levels of user access
- Scientific issues: Data ownership/sharing/publication
- Database issues: curation, federation: ontology, formats
- Ontology, “controlled vocabulary” incompatibilities (NeuroLex, CDE)

Welcome to NeuroLex, the Neuroscience Lexicon.

A dynamic lexicon of 33,383 neuroscience terms , including 752 neurons and 1290 parts of the nervous system
supported by The Neuroscience Information Framework and the International Neuroinformatics Coordinating Facility

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Find a Term!

Show me a Random Term!

All Categories A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Enter text into box to create your new page.

Create a new cell
Create a new brain region
Create a new resource
Create a new generic

HIERARCHIES

- Behavioral Activity
- Behavioral Paradigms
- Brain Regions
- Cells
- Neurons
- Diseases
- Imaging protocols
- Molecules
- Nervous System Function
- Subcellular Parts
- Resource Types
- Qualities

TABLES

- Behavioral Activity
- Behavioral Paradigms
- Brain Regions
- Overlapping Brain Regions
- Brain parcels
- Cell Types
- Diseases
- Molecules
- Nervous System Function
- Neurons
- Neurons by Neurotransmitter
- Organisms
- Resources and Information Entities
- Subcellular Parts
- Techniques
- Qualities
- Tissue banks
- Problem neural structures
- DICOM standard terms

The NeuroLex project, supported by the Neuroscience Information Framework project, is a dynamic lexicon of neuroscience terms. Unlike an encyclopedia, a lexicon provides the meaning of a term, and not all there is to know about it.
The NeuroLex is being constructed to help improve the way that neuroscientists communicate about their data, so that information systems like the NIF can find data more easily and provide more powerful means of integrating data that occur across distributed resources. One of the big roadblocks to data integration in neuroscience is the inconsistent use of terminology in databases and other resources like the literature. When we use the same terms to mean different things, we cannot easily ask questions that span across multiple resources. For example, if three databases have information about what genes are expressed in cortex, but they all use different definitions of cerebral cortex, then we cannot compare them easily.

As part of the NIF, we provide a simple search interface to many different sources of neuroscience information and data. To make this search more effective, we are constructing ontologies to help organize neuroscience concepts into category hierarchies, e.g., neuron is a cell. These

Contribution Scores

Last 30 days (Top 10)

Score	Pages	Changes	Username
675	645	863	Aarnaud (Talk | contribs)
46	39	51	Memartone (Talk | contribs)
39	39	39	Jugama (Talk | contribs)

NIF NAVIGATOR

DATA TYPE →
Animals (1607452)
Annotation (22495494)
Antibodies (2247176)
Atlas (267687887)
Biospecimen (638)
Brain Activation Foci (3241980)
Cell line (292624)
Clinical Trials (349804)
Connectivity (64204)
Dataset (27562738)
Disease (71422803)
Drugs (38334733)
Expression (557886935)
Gene (1395537)
Grants (2940718)
Images (489750)
Interactions (747514)
MRI (2831)
Microarray (578219126)
Models (1214650)
Molecule (76)
Multimedia (81553)
Orthology (9895886)
Pathways (801442)
People (367)
Phenotype (2129852)
Plasmids (30432)
Protocols (292)
Software (2026)

NIF REGISTRY (12823)

LITERATURE (23672833)

Powered By NIF

The list below is automatically generated by a query that extracts the definitions from classes that are children of the class "Regional part of brain". There are 905 classes here. This list is also available as CSV.

- A list of only brain regions in NeuroLex with definitions is available here.

A

- Abducens nerve fibers
- Abducens nerve root
- Abducens nucleus
- Accessory abducens nucleus
- Accessory basal amygdaloid nucleus
- Accessory cuneate nucleus
- Accessory medullary lamina
- Accessory nerve fiber bundle
- Adenohypophysis
- Aggregate regional part of brain
- Alar central lobule
- Allocortex
- Alveus
- Amiculum of dentate nucleus
- Amygdala
- Amygdala of Macaque
- Amygdala of PHT00
- Angular gyrus
- Annectant gyrus
- Ansa lenticularis
- Ansoparamedian fissure
- Antenna lobe of Manduca
- Anterior Paravermal Cortex
- Anterior amygdaloid area
- Anterior cingulate cortex
- Anterior cingulate gyrus
- Anterior column of fornix
- Anterior commissure anterior part
- Anterior commisure
- Anterior horn of lateral ventricle
- Anterior hypothalamic region
- Anterior limb of internal capsule
- Anterior lobe of the cerebellum

I CONT.

- Inferior horn of the lateral ventricle
- Inferior occipital gyrus
- Inferior occipital sulcus
- Inferior olivary complex
- Inferior parietal cortex
- Inferior pulvinar nucleus
- Inferior rostral gyrus
- Inferior temporal gyrus
- Inferior transverse frontopolar gyrus
- Inferior vestibular nucleus
- Infracerebellar nucleus
- Infundibular stem
- Insula
- Interanterodorsal nucleus of the thalamus
- Intercalated amygdaloid nuclei
- Intergeniculate leaflet of the lateral geniculate complex
- Intermediate acoustic stria
- Intermediate hypothalamic region
- Intermediate oculomotor nucleus
- Intermediate orbital gyrus
- Intermediate part of hypophysis
- Intermediate periventricular nucleus
- Intermediodorsal nucleus of the thalamus
- Internal arcuate fiber bundle
- Internal capsule
- Internal medullary lamina of thalamus
- Interpeduncular nucleus
- Interpolar part of spinal trigeminal nucleus
- Interpositus Nucleus
- Interstitial nucleus of Cajal
- Interstitial nucleus of the posterior limb of the anterior commissure
- Interthalamic adhesion

P CONT.

- Periamygdaloid area
- Periamygdaloid cortex
- Periaqueductal gray
- Pericalcarine cortex
- Pericentral nucleus of inferior colliculus
- Periolivary nucleus
- Peripeduncular nucleus
- Perirhinal cortex
- Peritrigeminal nucleus
- Pineal body
- Piriform cortex layer 1a
- Piriform cortex layer 1b
- Planum polare
- Pons
- Pontine nuclear complex
- Pontine raphe nucleus
- Pontine reticular formation
- Pontine tegmentum
- Pontobulbar nucleus
- Postcentral gyrus
- Postcommissural fornix
- Posterior calcarine sulcus
- Posterior cingulate cortex
- Posterior cingulate gyrus
- Posterior column of fornix
- Posterior horn lateral ventricle
- Posterior hypothalamic region
- Posterior limb of internal capsule
- Posterior lobe of the cerebellum
- Posterior median eminence
- Posterior nuclear complex
- Posterior nucleus of hypothalamus
- Posterior nucleus of thalamus

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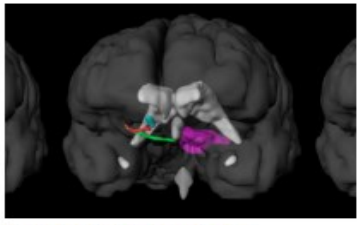
European Population Imaging Infrastructure

The mission of population imaging is to help develop and implement strategies to prevent or effectively treat disease through creation of a world class imaging research infrastructure within or in close vicinity to large population studies in the Netherlands and Europe. By shifting the focus from curative to preventive medicine, it will in the short-term improve people's quality of life and in the long-term reduce the costs for the healthcare sector.

EIBIR SUMMER SCHOOL on Neurology Imaging

28 January 2013

August 26-30, 2013, Dubrovnik / HR GOAL: The EIBIR Summer School on Neurology Imaging is a multidisciplinary summer school, uniting 50 young researchers coming from a variety of backgrounds. The high scientific level and the relaxed atmosphere invite a close and fruitful interaction between everybody



The Perspectief Program "Population Imaging Genetics (ImaGene)" has been granted

30 November 2012

Objective of the Program: The objective of the Program is to develop and evaluate novel methods to fully exploit imaging and genetics data from population studies in an integrated manner, for (early) disease detection, diagnosis, prognosis, therapy planning and therapy

Medical Delta dient aanvraag in bij EFRO voor versterking Population Imaging

30 November 2012

Medical Delta heeft een aanvraag ingediend bij het Europees Fonds voor Regionale Ontwikkeling van de Europese Commissie (EFRO) om haar positie op het gebied van Population Imaging verder te versterken. Population Imaging is het systematisch maken en analyseren

Boudewijn Lelieveldt has been appointed professor

30 October 2012

On 19 October, Boudewijn Lelieveldt (EEMCS) delivered his inaugural address as a professor of Biomedical Imaging at TU Delft and LUMC. In his address, Lelieveldt stated that medical science can often make excellent use of technologies from other fields. For example, knowledge from automatic facial recognition can also be used for

Large Cohort Studies

UK

ABC and LBC

Aberdeen and Lothian Birth Cohorts – Scottish Brain Image Bank

Study website: www.abdn.ac.uk/aberdeen-birth-cohort/
Organization website: www.abdn.ac.uk
Study population size: ABC: **653** participants, LBC: **729** participants
Study population: **healthy participants,** 65-75 years old
Imaging modality 1: **MRI** – Brain MRI

Key publications:

- Leaper SA, et al. Neuropsychologic correlates of brain white matter lesions depicted on MR images: 1921 Aberdeen Birth Cohort. Radiology, 2001.
- Staff RT, et al. What provides cerebral reserve? Brain, 2004.
- Murray AD, et al. Brain white matter hyperintensities: relative importance of vascular risk factors in nondemented elderly people. Radiology, 2005.
- Staff RT, et al. Brain volume and survival from age 78 to 85: the contribution of Alzheimer-type magnetic resonance imaging findings. J Am Geriatr Soc, 2010.

Spinal MR study

Study website: n.a.
Organization website: www2.warwick.ac.uk
Study population size: **25000** participants
Study population: **patients referred for back pain**
Imaging modality 1: **MRI** - Spinal MR

Key publications: not yet available.

UK Biobank

Study website: www.ukbiobank.ac.uk
Organization website: www.ctsu.ac.uk
Study population size: **500000** participants
Study population: **healthy participants,** 40-69 years old
Imaging modality 1: **MRI** – Cardiac and abdominal MR
Imaging modality 2: **Ultrasound** – Carotid

Key publications:

- Allen N, et al. UK Biobank: Current status and what it means for epidemiology. Health Policy and Technology, 2012.
- UK Biobank. UK Biobank: rationale, design and development of a large-scale prospective resource, ‹http://www.ukbiobank.ac.uk/resources/›
- Murray AD, et al. The UK Biobank sample handling and storage protocol for the collection, processing and archiving

France

3C Study

The Three-City Study

Study website: www.three-city-study.com/the-three-city-study.php
Organization website: www.upmc.fr
Study population size: **9294** participants
Study population: **healthy population**, aged 65 years and older
Imaging modality 1: **ultrasound** - Carotid-IMT
Imaging modality 2: **MRI** – Brain MRI

Key publications:

- The 3C Study Group. Vascular factors and risk of dementia. Design of the Three-City Study and baseline characteristics of the study population. Neuroepidemiology, 2003.
- Elbaz A, Ripert M, et al. Common carotid artery intima-media thickness, carotid plaques, and walking speed. Stroke, 2005.
- Ritchie K, Carrière I, et al. The neuroprotective effect of caffeine: a prospective population study (The Three City Study). Neurology, 2007.
- Godin O, Dufouil C, et al. White matter lesions as a predictor of depression in the elderly- The 3C-Dijon study. Biological Psychiatry, 2008.
- Maillard P, Delcroix N, et al. An automated procedure for the assessment of white matter hyperintensities on multispectral (T1, T2, PD) MRI and its between-centre reproducibility evaluation on two large community databases. Neuroradiology, 2008.
- Debette S, Bis JC, et al. Genome-wide association studies of MRI-defined brain infarcts: meta-analysis from the CHARGE Consortium. Stroke, 2010.
- Stewart R, Godin O, et al. Longitudinal neuroimaging correlates of subjective memory impairment: 4-year prospective community study. Br J Psychiatry, 2011.

EVA Study

The Epidemiology of Vascular Aging Study

Study website: n.a.
Organization website: n.a.
Study population size: **1389** participants
Study population: **healthy population**, aged 59 – 71 years old
Imaging modality 1: **ultrasound** – carotid-IMT
Imaging modality 2: **MRI** – Brain MRI

Key publications:

- Bonithon-Kopp C, Touboul PJ, et al. Relation of Intima-Media Thickness to Atherosclerotic Plaques in Carotid Arteries
  The Vascular Aging (EVA) Study. Arterioscler Thromb Vasc Biol, 1996.
- Dufouil C, Ducimetière P, et al. Sex differences in the association between alcohol consumption and cognitive performance. EVA Study Group. Epidemiology of Vascular Aging. Am J Epidemiol, 1997.
- Tzourio C, Dufouil C, et al. Cognitive decline in individuals with high blood pressure: a longitudinal study in the elderly. EVA Study Group. Epidemiology of Vascular Aging. Neurology, 1999.
- Dufouil C, de Kersaint-Gilly A, et al. Longitudinal study of blood pressure and white matter hyperintensities: the EVA MRI Cohort. Neurology, 2001.
- Pico F, Dufouil C, et al. Longitudinal study of carotid atherosclerosis and white matter hyperintensities: the EVA-MRI cohort. Cerebrovasc Dis. 2002.

Netherlands

BIG project

The Nijmegen Brain Imaging Genetics (BIG) project

Study website: www.cognomics.nl/big
Organization website: www.ru.nl
Study population size: **2500** participants
Study population: **healthy population**, aged 45 and older
Imaging modality 1: **MRI** – Brain

Key publications:

- Bralten J, Arias-Vásquez A, et al. Association of the Alzheimer's gene SORL1 with hippocampal volume in young, healthy adults. American Journal of Psychiatry. 2011.
- Hoogman M, Rijpkema M, et al. Current self-reported symptoms of attention deficit/hyperactivity disorder are associated with total brain volume in healthy adults. PLoS One. 2012.

Generation R Study

Study website: www.generationr.nl
Organization website: www.erasmusmc.nl
Study population size: **10000** participants.
Study population: **healthy children**, from birth and on.
Imaging modality 1: **ultrasound** - Fetal, abdominal, thoracic
Imaging modality 2: **MRI** - brain, subgroup.

Key publications (see also: www.generationr.nl/researchers/phd-theses-and-publications.html):

- Jaddoe VW, van Duijn CM, et al. The Generation R Study: design and cohort update 2012. Eur J Epidemiol. 2012.
- Tiemeier H, Velders FP, et al. The Generation R Study: A review of design, findings to date, and a study of the 5-HTTLPR by environmental interaction from fetal life onward. J Am Acad Child Adolesc Psychiatry. 2012.

Maastricht Study

Study website: www.demaastrichtstudie.nl
Organization website: www.maastrichtuniversity.nl
Study population size: **10000** participants (expected; study started in 2010, imaging started end 2012).
Study population: **5000** with **diabetes mellitus type 2, 5000 healthy** participants, aged 40-75 years.
Imaging modality 1: **ultrasound** - Abdominal fat, cardiac
Imaging modality 2: **plain radiographs** - Knee
Imaging modality 3: **DEXA** - Body composition
Imaging modality 5: **CT** - Coronary calcium scoring, Coronary CTA (*future plans*)
Imaging modality 5: **MRI** – Brain, body fat quantification, carotids

Key publications: not yet available.

NELSON Study

Nederlands-Leuvens Longkanker Screenings Onderzoek

Study website:www.nelsonproject.nl