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The Internet Brain Volume Database: A Public Resource for Storage and Retrieval of Volumetric Data

David N. Kennedy,
Division of Neuroinformatics and the Child and Adolescent NeuroDevelopment Initiative (CANDI), Department of Psychiatry, University of Massachusetts Medical School, 356 Plantation St, Biotech 1, Suite 100, Worcester, MA 01605, USA

Steven M. Hodge,
Division of Neuroinformatics and the Child and Adolescent NeuroDevelopment Initiative (CANDI), Department of Psychiatry, University of Massachusetts Medical School, 356 Plantation St, Biotech 1, Suite 100, Worcester, MA 01605, USA

Yong Gao,
Department of Neurology, Massachusetts General Hospital, Boston, MA, USA

Jean A. Frazier, and
Division of Neuroinformatics and the Child and Adolescent NeuroDevelopment Initiative (CANDI), Department of Psychiatry, University of Massachusetts Medical School, 356 Plantation St, Biotech 1, Suite 100, Worcester, MA 01605, USA

Christian Haselgrove
Division of Neuroinformatics and the Child and Adolescent NeuroDevelopment Initiative (CANDI), Department of Psychiatry, University of Massachusetts Medical School, 356 Plantation St, Biotech 1, Suite 100, Worcester, MA 01605, USA

David N. Kennedy: David.Kennedy@umassmed.edu

Abstract

Every month, numerous publications appear that include neuroanatomic volumetric observations. The current and past literature that includes volumetric measurements is vast, but variable with respect to specific species, structures, and subject characteristics (such as gender, age, pathology, etc.). In this report we introduce the Internet Brain Volume Database (IBVD), www.nitrc.org/projects/ibvd, a site devoted to facilitating access to and utilization of neuroanatomic volumetric observations as published in the literature. We review the design and functionality of the site. The IBVD is the first database dedicated to integrating, exposing and sharing brain volumetric observations across species and disease. It offers valuable functionality for quality assurance assessment of results as well as support for meta-analysis across large segments of the published literature that are obscured from traditional text-based search engines.

Keywords

Brain; Volume; Quantitative neuroanatomy; Morphometry; Database; Website

Correspondence to: David N. Kennedy, David.Kennedy@umassmed.edu.

Information Sharing Statement
The website described in this report is currently accessible at www.cma.mgh.harvard.edu/ibvd and www.nitrc.org/projects/ibvd.

Introduction

In this report we introduce the Internet Brain Volume Database (IBVD). Instantiated as a web-accessible database (www.cma.mgh.harvard.edu/ibvd and www.nitrc.org/projects/ibvd), this site is devoted to facilitating discovery and access to neuroanatomic volumetric observations as published in the literature. The IBVD is the first database dedicated to integrating, exposing, and sharing brain volumetric observations across species and disease. The current objective is to demonstrate the utility of a database of neuroanatomic volumetric observations from the literature. This database is initiated through a manual, retrospective review and entry of the pertinent literature in order to evaluate the system design for this endeavor. Once successful, future extensions will be necessary to enable a long term, sustainable, prospective data capture solution that will likely involve the active participation of the authors and publishers.

Every month, on the order of 10 publications appear that include neuroanatomic volumetric observations. The current and past literature that includes volumetric measurements is vast, but variable with respect to specific species, structures, and subject characteristics (such as gender, age, pathology, etc.). In general, much more has been published regarding quantitative neuroanatomy in the human as compared to other species. The advent of magnetic resonance imaging (MRI) opened a impressive opportunity to make precise, noninvasive, in-vivo measurements in many subject populations (Caviness et al. 1999).

Quantitative morphometric studies have been performed in virtually every neurologic and psychiatric disorder (for example (Seidman et al. 2002; Courchesne and Pierce 2005; Rosas et al. 2005; Seidman et al. 2005; Leow et al. 2009; Schuff et al. 2009)). Of course, tantamount to understanding the neuroanatomic changes that are related to pathological conditions is the need to have a precise understanding of normative neuroanatomic development (Caviness et al. 1996; Thompson et al. 2000; Saitoh et al. 2001; Salat et al. 2004; Casey et al. 2005; Giedd et al. 2006; Lenroot et al. 2007). While substantial imaging archives of raw data are being assembled (Mazziotta et al. 2001; Marcus et al. 2007; Waber et al. 2007; Jack et al. 2008), access to the quantitative derived data, specifically as it becomes utilized in the published literature, is still greatly underserved.

Since thousands of individual measurements of brain structures have been made and reported, it is impossible for individual researchers to maintain a working knowledge of the effective ‘view’ supported by the literature of exactly how large a specific neuroanatomic structure should be (given a species, age, gender, imaging technique, analysis technique, etc.). Since there are many factors that effect the measurements and results, there is a substantial need to be able to evaluate the relative contributions of these factors to a true, unbiased estimate of brain structural volume. Such an assessment is served through the application of meta-analysis to the results of individual studies in order to derive the prevalence of true underlying biological effects in relation to methodological (subject, sampling, acquisition, analysis, etc.) sources of variance (Bzdok et al. 2011; Jardri et al. 2011). Sites like the IBVD are designed to specifically support such broad, literature-based assessment.

In this report we review the database design and web-based user interface for the IBVD. We describe the current status of data entry into the system, and provide examples of the types of meta-analyses that are subsequently supported by the system. The prospects and challenges for moving this type of analysis scheme forward are then discussed.

Methods

IBVD is a web application implemented in PHP on top of a PostgreSQL database. The database schema, shown in Fig. 1, is designed to capture the complete set of information necessary to describe a volumetric observation in the literature. The conceptual starting point for this description is the 'publication' itself. Publications typically describe the demographic characteristics of 'Groups' of subjects, and then report 'Group Volumes' for some set of anatomic structures. In addition, individual subjects that comprise the Groups may be described in terms of their 'Individual Demographic' and 'Individual Volume' observations. While bulk uploading of standardized text representations of data is supported, Fig. 2 shows the user interface for each of these web-based entry forms.

Data fields are a mixture of forced choice selection, automated entry, and free text of various formats. For example, given the PubMed identifier (PMID) of a publication, the IBVD gathers information about the publication using the NCBI Entrez Utilities Web Services and automatically populates the IBVD Publication data fields. In addition, species, anatomic region, units or measurement, and numerous of the clinical and behavioral characteristics are filled from specific selection lists. The use of a structured vocabulary is necessary in order to maximize the interoperability of this site with other data resources. Structures, from the whole brain to major subdivisions (e.g. cerebrum) to components of these major regions (e.g. cerebral cortex, white matter) to subcomponent within these regions (e.g. precentral gyrus), are mapped into this ontology. All concepts, such as diagnosis, anatomic region, etc. also can have a concept identification code associated with them (i.e. from Unified Medical Language System, UMLS; or NeuroLEX) to facilitate database mediation and integration (Lindberg et al. 1993; Bowden and Dubach 2003; Bug et al. 2008; Gardner et al. 2008; Larson and Martone 2009). Figure 3 shows a completed example of the linked data pages that span from the publication to the individual volumetric measurements. A data dictionary with the field definitions is provided in the Appendix.

Website Functions

From the website homepage, the user can access all major site functions. These include: registered user login (required only for data entry), data entry, data display and database search functions. Results of each search can be visualized by a plot of volume by age with various display options, or exported for additional off-line processing and analysis. Searching is facilitated by a specification form, where the user can specify specific group or individual criteria, including: diagnosis; anatomic region; age range; handedness; gender; species; and hemisphere. Visualization plots feature volume as a function of age, where x and y error bars represent age and volume standard deviations, respectively. Plot symbols and colors can be selected to represent the various characteristics of the search result, such as diagnosis, gender, structure, etc.

Results

In this section we will demonstrate the current status and some of the features of the database.

Data Entry

Data entry statistics (as of 06/2011) include: 647 publications, 1,598 subject groups, 9,699 group volume entries, over 80 clinical diagnoses, 1,939 individuals, 10,215 individual structural volume entries, and over 90 discrete brain structures. Note that at this time, most data is reported in the literature for groups of subjects, and inclusion of the volumetric data for each of the individuals within a group is relatively uncommon (although this should be encouraged). Tables 1 and 2 list the most common diagnoses and structures in order of prevalence in the database.

Example Queries

The most efficient way to see the effectiveness of the database is to view the graphical results of typical queries. Figure 4 demonstrates the results of the volumetric results returned for subject groups indicated as ‘normal’ for total brain, total cerebral gray and white matter, right and left caudate nucleus, and right and left hippocampus. Note that Fig. 4b–d did not select for the gender makeup or specific methodology employed for the reported volumes, although each of these factors can be included in the search criteria.

Additional insight into the content of the database comes from viewing results of studies of specific pathologies, in isolation or taken across the literature. An example of this is shown in Fig. 5, where the ‘Paper View’ functionality is used to show the results of Herbert et al. 2003 (Herbert et al. 2003) relative to the rest of the literature. In this example, for the anatomic structure ‘total brain volume’, in one plot we can see the consistency for the normal group from this paper with the rest of the literature.

Discussion

The IBVD is a work in progress. The principal objective is to provide a database of neuroanatomic volumetric data as reported in the literature. In addition, we provide a mechanism to facilitate its review, discovery and extension as part of an overall neuroinformatics infrastructure designed to expose deeper, non-textual aspects of the published neuroscience data. The current instantiation provides a proof of concept for the utility of the site and generates substantial feedback and guidance for design of a long term, sustainable solution to this type of specialized data repository.

In its current state, while covering only a small percentage of the total set of published volumetric observations, the database can be shown to be useful for performing confirmative and integrative assessments of new and existing data. Despite the myriad methods for generating volumetric observations (different imaging, analysis, subject characterization, etc.), the IBVD demonstrates that specific neuroanatomic structures are relatively insensitive to the specific assessment methodological details. In contrast, other structures are demonstrated to be quite sensitive to the analysis methodological details. Qualitatitively, for each structure we can assess the between group volume standard deviation relative to the within group standard deviation, regardless of the analysis method employed. Examples of each of these classes of structure are seen in Fig. 4 with the cerebrum and hippocampus volume plots, respectively. The potential reasons for substantial methodological variability in the hippocampus are numerous. First, it is a relatively small structure (approximately 8 cc in young adults), which magnifies sensitivity to all acquisition and analyses sources of variance (Filipek et al. 1994). Second, numerous of its borders are open to methodological interpretation (Konrad et al. 2009; Rodionov et al. 2009). These are also often modulated by available imaging resolution. Specifically, the nature of the handling of the hippocampus—amygdala border can be variable, as can the extent to which the hippocampus definition includes entorhinal cortex, subiculum, perirhinal cortex, etc. In providing the ability to present a literature-wide normative ‘growth curve’ of specific neuroanatomic structure volume, the observer has quick access to an assessment of that structures volumetric measurement ‘stability’. In this case, stability refers to the relative insensitivity of the volumetric measures with respect to the methodological variables. Extra caution is warranted in the interpretation of the relative literature values for structures that demonstrate clear methodological dependence.

It is important to note that the proof of concept of this class of data extraction and mining from the historical literature is feasible and informative, but it is clear that new published reports would benefit greatly from a prospective approach to data entry. In addition, continued harvesting of information from historical publications, as well as new publications, could take advantage of automated text recognition software, designed to identify neuroanatomic structures in association with volumetric observations in the literature (Muller et al. 2008). The most feasible approach to systematic and automated incorporation of volumetric data from future publications is to promote the analytic capture in a standardized format of the detailed metadata of the volumetric observations in machine-readable form at time of publication. It is at the time of the accepted, but not yet published, manuscript where the authors are most familiar with, and amenable to, content markup. Establishment of a standardized markup language for volumetric observations (VolML), and creation of simple, easy-to-use tools for expressing data in this form, using volume tables or output of volumetric analysis software directly as input, will be critical to moving this endeavor forward.

Interoperability

While the free-standing IBVD website provides valuable functionality to the user, its utility is also demonstrated through its interoperations with other websites. The IBVD is used to provide a "Size Differences by Sex, Age and Diagnosis" link out of the Braininfo website[1] (Bowden and Dubach 2003). In addition, since all IBVD publications have an associated PubMed ID, the IBVD publication page can be associated with the PubMed page for each article in the 'LinkOut' resource listing.[2] This capability is mediated by the Neuroscience Information Framework (NIF) DISCO LinkOut Broker framework (Marenco et al. 2008). Finally, IBVD is part of the NIF 'data federation', enabling direct query of the database in the context of the integrated NIF search portal[3] (Gardner et al. 2008).

The IBVD is the first, to our knowledge, database specifically designed to host neuroanatomic volumetric observations from the published literature. As such, it captures a specific class of derived result that is reported in the literature; such results are not specifically searchable by the existing text-based indexing services. Other databases have been developed to capture different classes of derived data in the literature, of particular note are the databases designed hold to the Talairach coordinates of foci identified in functional neuroimaging activation studies (i.e. BrainMap (Laird et al. 2005), SumsDB (Van Essen 2009)).

The IBVD is not a replacement or alternative to data storage efforts designed to host raw imaging data. Indeed, the IBVD can be a useful conduit to help connect volumetric observations in the literature to the raw data sources, when available. While reanalysis of raw data is important for many reasons, the archiving of raw data is a different informatics problem than the one addressed here. Each group and individual volume data record includes a 'url' field that permits association between the volume observation and the raw data that leads to the observation. It is important to note, however, that it is the conclusions and observations that are made in a paper that persist and become the points for comparison in future publications, even decades later. This database supports the specific retention of the resultant volumetric data that supports these discussion and conclusion points for easier future reference.

[1] http://braininfo.rprc.washington.edu/
[2] See http://www.ncbi.nlm.nih.gov/pubmed/18003631, for example.
[3] http://neuinfo.org/

Only limited graphics and no statistical analysis are offered via the IBVD website itself. This is intentional, as providing full-featured capabilities in either of these areas would entail a substantial investment in infrastructure development. It was felt that, since graphical and statistical treatment are much better handled by numerous separate applications, the focus of the IBVD should be to provide interoperable export of data for use in these other packages. The complete results of any search can be exported, as a tab (or other custom separator) separated value file, for incorporation into any statistics or visualization software. As an example of this, Fig. 6 demonstrates the results of an analysis in the 'R' statistical package[4] for the generation of a continuous 'growth curve' for the total cerebellum volume in humans. To accomplish this, any dataset found as the result of a search in IBVD can be downloaded as a PHP table, which can be imported into R. In this example, the contributed package 'ggplot2' (Wickham 2009) is used to model the collection of volume data by a third order polynomial of age to estimate growth across the lifespan. Confidence bands and a weighting factor of study size are also incorporated into the graphic. In summary, while there is no fully featured web service, IBVD provides a complete text-based access to the publication, group demographic, and group volume tables. The relative simplicity of the database schema makes this a viable solution. Development of a more complex API is awaiting future release.

Limitations

While this report focuses on the underlying design and implementation of the database, support of broad and numerous studies of meta-analysis are envisioned for future publications. However, support of meta-analysis is predicated on coverage of the appropriate literature for the specific topic. To date, the data entry approach has been to enter example literature for the most prevalent volumetric structures and disorders. Efforts are ongoing to increase the content of the database, and targeted data entry will be necessary to facilitate specific meta-analytic investigation of the historical literature on the volumetric observations of the developing brain. The manual data entry described here is moderately time consuming. A publication takes approximately 10 s to enter (only the PubMed ID needs to be typed). A typical 'group' record takes about 2 min, depending on the number of demographic values reported. Most papers have between 2 and 10 groups, with an average of 3.2 groups per publication. Each volumetric record takes approximately 30 s to enter. Groups have from 1 to as many as 52 volumetric observations (with a mean of 6.1 volumes per group). With the addition of site navigation time, a typical paper takes 20–30 min of data entry. Data entry is preceded, however, by careful study and identification of all relevant data items in the paper. Volume and demographic data must be identified in both tabular and text contexts. This identification phase can take 30 min for typical volumetric papers.

Numerous extensions to the basic database can readily be envisioned. Inclusion of a new table to monitor the statistical comparisons between group volumetric reports can be envisioned. This would characterize the nature of the statistical test, the notation of which volumetric observations were tested and what covariates were included, and capture the significance of the reported findings. In addition, since growth curves and comparison of curves between diagnostic classes are a very common end use for the data, a better integration of the data export into a dedicated statistical interface to support growth curve generation would greatly facilitate database usage.

Precise identification of the volumetric analysis method employed is one of the most complex tasks associated with the characterization of a volumetric publication. In the absence of a formal ontology or description language for a set of anatomic definitions, we

[4]http://www.R-project.org

have chosen to represent the method of analysis by reference to the publication that best characterizes the anatomic method employed in the paper. ‘Method ID’ is available as a plotting factor for the results of searches in the database. The database does include a free text notes field for each publication. Methodological details can be included in this field. Standard terms and descriptions that should be should be considered for method description include imaging descriptors (i.e. field strength, imaging resolution, pulse sequence, software, etc. for MR data) as well as software description and the anatomic conventions employed, etc. Additional work is ongoing to create a more formal methodological description framework.

Despite the prevalence of volumetric observations in the literature, the presence of ‘voxel-based’ morphometric observations are rapidly eclipsing the volumetric observations in terms of sheer observations due in part to the ease of application of VBM-style analyses. While VBM between-group statistical inferences do not result in volumetric results for anatomic structures per se, the presence or absence of VBM findings localized to specific structures is a very valuable adjunct to the observations of structural differences between the same contrast groups. Fortunately, there are existing databases for capture of voxel-based group differences that have been developed for the capture of fMRI foci (i.e. BrainMap (Laird et al. 2005), SumsDB (Van Essen 2009)), and these have on-going extensions to capture voxel-based morphometric results as well. Future efforts to create blended reports of volumetric and voxel-based morphometric observations are proceeding.

Conclusion

In summary, the IBVD is an operational proof of concept of a domain-specific metadata capture system designed to operate on the published literature of neuroanatomic structural volumetric observations. Even in its prototypic stage, it supports quality assurance interrogation of results as well as meta-analysis across large segments of the published literature that are obscured from traditional text-based search engines.

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Appendix

In this appendix we review the details of the various database tables.

Publication

Data sources

In most cases, publications are journal articles, but they may be other sources of data, such as on-line databases.

ID	Integer	IBVD unique identifier for this publication.
Title	Text	Name of data source. Typically the title of the journal article, but this may be the name of a special data source (e.g. “Mouse Brain Library”).
Journal	Text	Journal name.
Date	Text	Date of publication.
Volume	Text	Journal volume/number.
Pages	Text	Page range for journal article.
URL	Text	URL for this publication or data source.

Author

Journal article authors.

Author name	Text	The name of an author
Credited	Integer	An ordinal giving the position of the author in the list of authors. The first author will have credited = 1, second author credited = 2, etc.

Group

Subject groups

Groups are reported on in publications. The groups can be associated with a reference for the volume measurement methods employed (manual techniques for measurement, algorithms, software packages, etc) by reference to the most representative publication.

ID	Integer	IBVD unique identifier for this subject group.
Method ID	Integer	IBVD Publication ID for publication(s) indicating methodology employed for this group.
Species	Text	Species of subjects in this group.
Species qualifier	Text	Subspecies of subjects in this group, for instance mouse strain.
Diagnosis	Text	Diagnosis of subjects in this group.
Vivoness	Text	Whether the volume measurement was done in vivo, in vitro, or ex vivo.
Number of subjects	Integer	Number of subjects in this group.
N male	Integer	Number of male subjects in this group.
N female	Integer	Number of female subjects in this group.
N left handed	Integer	Number of left handed subjects in this group.
N right handed	Integer	Number of right handed subjects in this group.
Mean age	Float	Mean age, in years, of subjects in this group.
Age std dev	Float	Standard deviation of ages, in years, of subjects in this group.
Age min	Float	Minimum age, in years, of subjects in this group.
Age max	Float	Maximum age, in years, of subjects in this group.
URL	Text	URL for this group (for on-line data sources or publications sharing data on-line).

Group volume

Reported volumes for subject groups.

ID	Integer	IBVD unique identifier for this reported volume.
Structure	Text	Structure being measured.
Hemisphere	Text	Hemisphere of the structure being measured (left, right, or total).
Mean volume	Float	Mean of volumes in this subject group.
Volume std dev	Float	Standard deviation of volumes in this subject group.
Units	Text	Units (ml, cc, etc) of the volume measurement.
Derived flag	Boolean	Whether this volume was derived from reported individual volumes. False for volumes directly reported in publications.
Adjusted flag	Boolean	Whether the reported measurement is stated to be ‘adjusted’ (for total brain volume, for example).
URL	Text	URL for this volume (for on-line data sources or publications sharing data on-line).

Extra group demographics

Reported demographics for subject groups. Basic demographic information is stored in the group table; this table provides extensibility for storing demographics.

ID	Integer	IBVD unique identifier for this extra demographic value.
Label	Text	The value being reported, for instance “Body Mass Index” or “Education Level.”

Qualifier	Text	Type of value being reported. This is unset for a direct measurement, but may indicate a mean, standard deviation, minimum, or maximum. In this way, an education level, say, of 12 +− 3 years may be stored.
Value	Text	The stored value.
Units	Text	Units of the stored value.

Individual

Individual subject demographic data. Individual subjects can be reported in association with a group.

ID	**Integer**	**IBVD unique identifier for this subject.**
Age	Float	Age, in years, of this subject.
Gender	Text	Gender of this subject.
Handedness	Text	Handedness of this subject.
Local code	Text	The source's identifier for this subject. This is used for identifying a subject in an on-line database.
Species	Text	Species of the subject.
Species qualifier	Text	Subspecies of the subject, for instance mouse strain.
Vivoness	Text	Whether the volume measurements for this subject were done in vivo, in vitro, or ex vivo.
URL	Text	URL for this subject (for on-line data sources or publications sharing data on-line).

Individual volume

Reported volumes for individual subjects. The individual volume record can report a volume measurement method (manual techniques for measurement, algorithms, software packages, etc) by reference to the most representative publication.

ID	**Integer**	**IBVD unique identifier for this reported volume.**
Method ID	Integer	IBVD Publication ID for publication(s) indicating methodology employed for this individual.
Structure	Text	Structure being measured.
Hemisphere	Text	Hemisphere of the structure being measured (left, right, or total).
Volume	Float	Reported volume.
Units	Text	Units (ml, cc, etc) of the volume measurement.
Derived flag	Boolean	Whether this volume was derived from other volumes. False for volumes directly reported in publications.
Adjusted flag	Boolean	Whether the reported measurement is stated to be 'adjusted' (for total brain volume, for example).
URL	Text	URL for this volume (for on-line data sources or publications sharing data on-line).

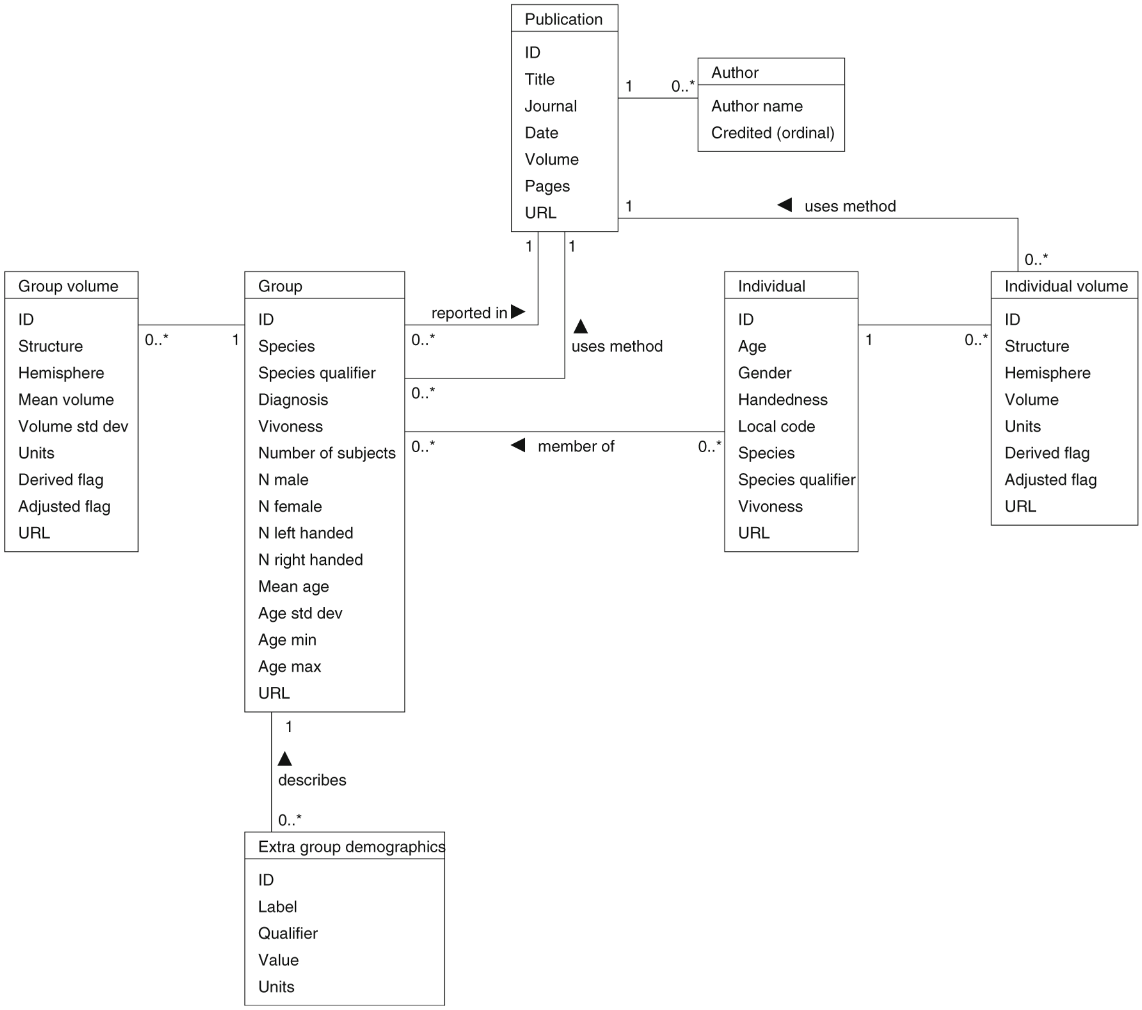


Fig. 1.
IBVD database schema. Demonstrating the structure and relationship of the database tables for Publication, Group, Group volume, Individual, and Individual volume. The Appendix provides a brief definition for each database element. The “0…” notation represents that multiple records (indexed 0, 1, 2, etc.) are permissible (i.e. a Group can have multiple group volume records associated with it). Conversely, the ‘1’ represents an exclusive relationship (i.e. a Group Volume can be associated with one and only one group)

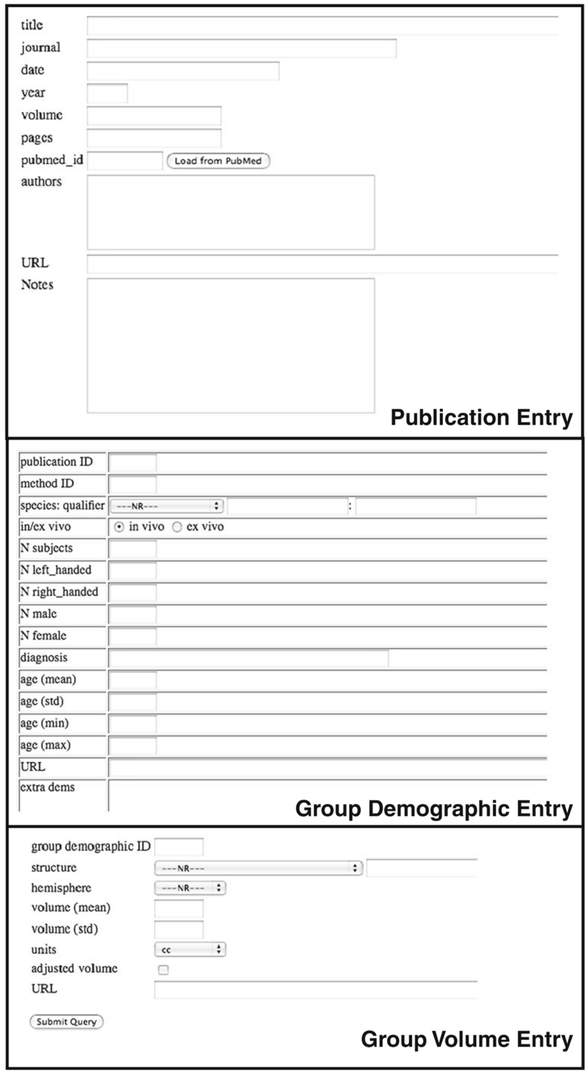


Fig. 2.

The user interface for each of these web-based entry forms. Includes forms for Publication, Group Demographic and Group Volume entry

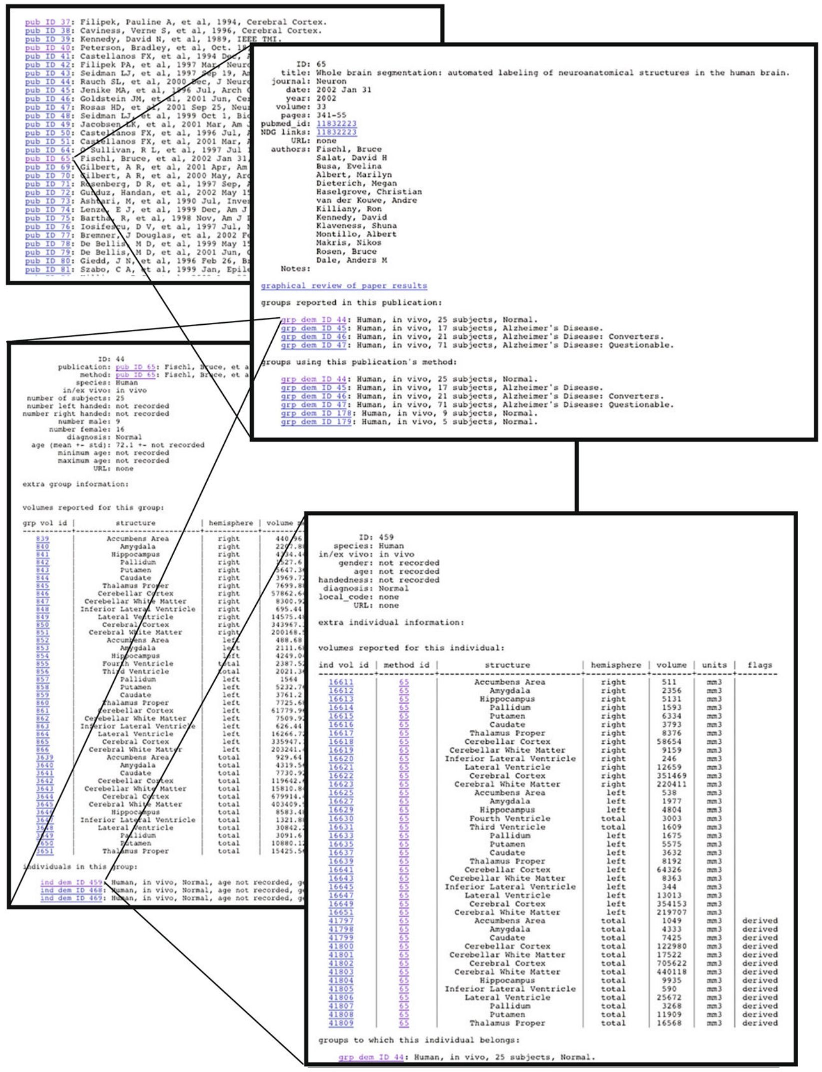


Fig. 3.

Linked example pages from publication record to individual data. Follows the sequential relationships between a specific publication entry, and drills down to the group volume record for one of the reported groups, and subsequently into the individual subject volume record for an individual within that group

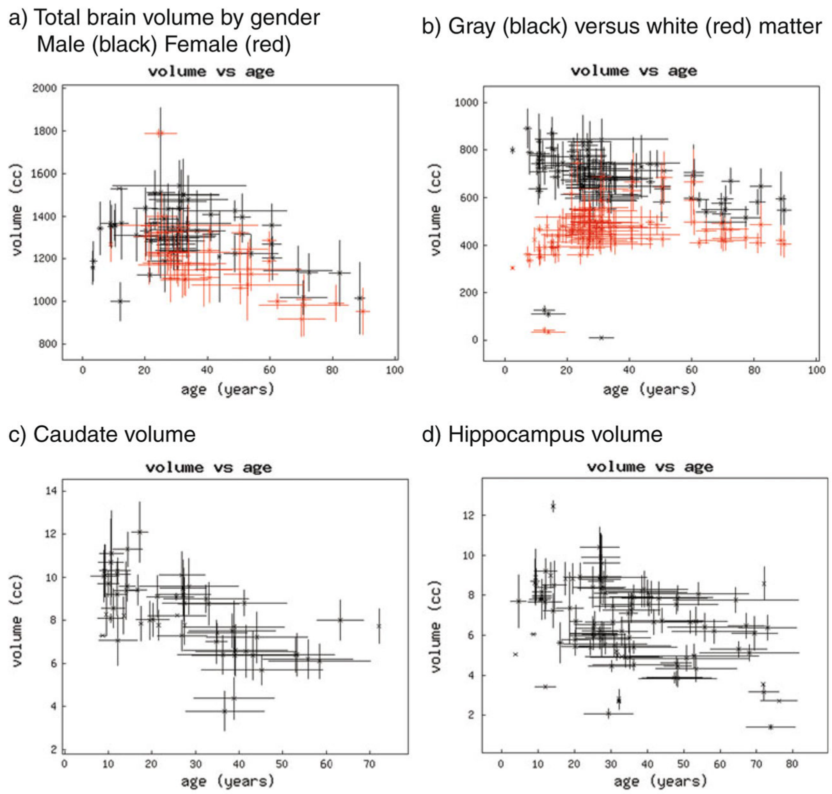
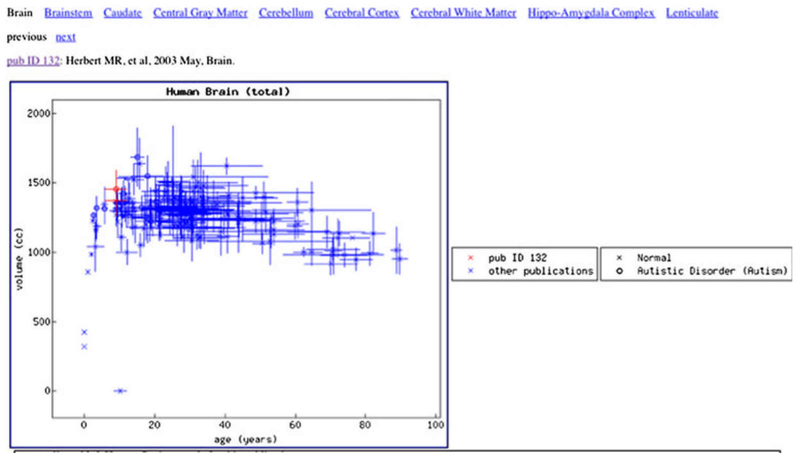


Fig. 4.

Graphical plots of sample query results. For these plots of group volume, each group is represented by the mean age (on the x axis) and mean volume (on the y axis). The x-axis bars represent the standard deviation of the reported group age; the y-axis bar represents the reported standard deviation of the volume. **a** Results of the volumetric results returned for subject groups indicated as 'normal' for total brain, plotted by gender. **b** Co-plot of total cerebral gray and white matter. **c** Plot of total caudate nucleus volume by age. **d** Plot of total hippocampus volume by age



Volume Details: pub ID 132

Diagnosis	N	Males/Females	Mean Age ± STD	Brain Volume ± STD
Autistic Disorder (Autism)	17	17/0	9 ± 3	1453.96 ± 136.98 cc
Normal	15	10/0	9 ± 3	1367.44 ± 106.17 cc

Fig. 5.

Demonstration of the ‘Paper View’ display for Herbert et al. 2003. Total brain volume is plotted; with the observations of this specific paper shown in *red*. Comparison volumes from the remainder of the database are shown in blue, and represent data for normal subjects (x) as well as groups with the diagnosis of Autistic Disorder (o)

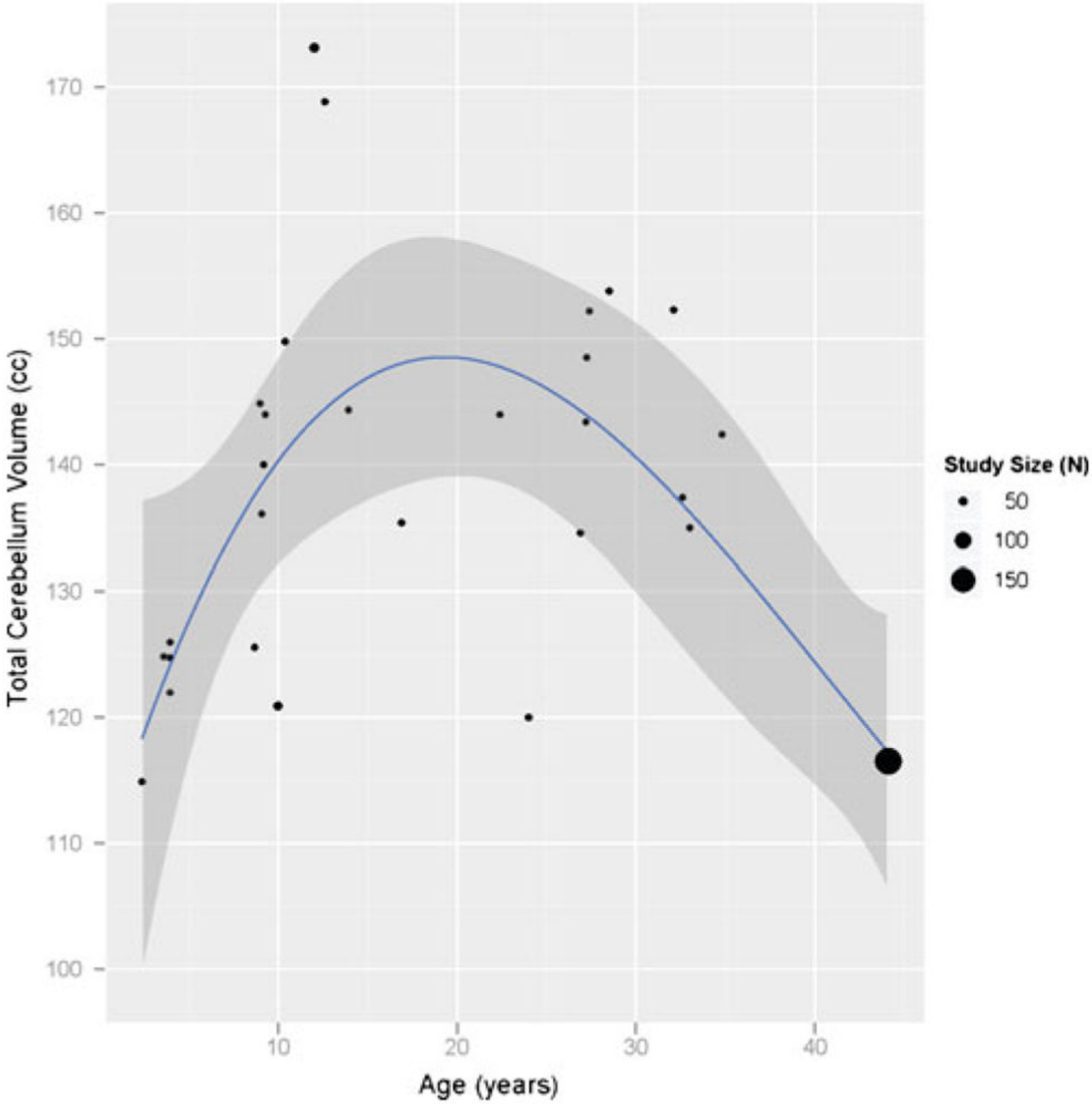


Fig. 6.
Growth curve for total cerebellum volume. Example statistical analysis for 3rd order polynomial fit in R for volume as a function of age from data exported from the IBVD

Table 1

IBVD content by diagnosis. Includes the number of groups with the diagnosis and the UMLS and DSM-IV correspondence

IBVD diagnosis	# Groups	UMLS CUI	DSM-IV code
Normal	767	NA	NA
Schizophrenia	97	C0392322	295.90
Autistic Disorder (Autism)	57	C0004352	299.00
Bipolar Disorder	45	C0005586	296.80
Major Depressive Disorder (Unipolar)	41	C0154409	296.30
Alzheimer’s Disease	37	C0002395	290.0
ADHD	18	C0004269	314.9
Alcohol Dependence	17	C0001973	303.9
Dementia	12	C0497327	294.8
Traumatic Brain Injury	9		
Obsessive Compulsive Disorder (OCD)	7	C0028768	300.3
Borderline Personality Disorder	7	C0006012	301.83
Asperger’s Syndrome	7	C0236792	299.80

Table 2

IBVD content by neuroanatomic structure. For each structure, the number of groups and individual volume records are indicated. Of these records, the numbers that are from 'normal' or 'pathological' diagnoses is indicated for group and individual are indicated

Structure	Groups	(Normal/Pathological)	Individuals	(Normal/Pathological)
Hippocampus	1263	(619/644)	513	(171/342)
Amygdala	790	(386/404)	429	(102/327)
Brain	624	(410/214)	1654	(1605/49)
Caudate	461	(237/224)	579	(252/327)
Putamen	304	(159/145)	429	(102/327)
Thalamus	301	(144/157)	82	(52/30)
Lateral Ventricle	299	(183/116)	576	(249/327)
Cerebrum	292	(160/132)	174	(161/13)
Gray Matter	260	(161/99)	2	(0/2)
White Matter	244	(160/84)	22	(0/22)
Intracranial	215	(102/113)	0	(0/0)
Temporal Lobe	208	(98/110)	0	(0/0)
Cerebellum	193	(113/80)	183	(183/0)
CSF	161	(96/65)	2	(0/2)
Pallidum	158	(90/68)	429	(102/327)
Cerebral White Matter	130	(79/51)	521	(194/327)
Ventricular System	130	(94/36)	234	(234/0)
Third Ventricle	119	(73/46)	143	(34/109)
Hippo-Amygdala Complex	100	(55/45)	0	(0/0)
Nucleus Accumbens	88	(46/42)	0	(0/0)
Corpus Callosum	85	(52/33)	92	(92/0)
Temporal Lobe (gm)	85	(49/36)	92	(92/0)
Cerebral Cortex	83	(54/29)	429	(102/327)
Cerebral Gray Matter	78	(52/26)	92	(92/0)
Frontal Lobe (gm)	69	(41/28)	92	(92/0)
Parietal Lobe (gm)	69	(41/28)	92	(92/0)
Fourth Ventricle	64	(48/16)	143	(34/109)
Occipital Lobe (gm)	63	(36/27)	92	(92/0)
Frontal Lobe	60	(34/26)	0	(0/0)
Inferior Lateral Ventricle	56	(37/19)	429	(102/327)
Brainstem	51	(37/14)	9	(9/0)
Entorhinal Cortex	50	(27/23)	0	(0/0)