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An Application of a Functional Magnetic Resonance Imaging Database

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Background and Purpose

Databases have been instrumental in the fields of biology (GenBank and Protein Data Bank) and astrophysics (Sloan Digital Sky Survey). Over the last ten years, brain-imaging studies have dramatically transformed the field of neuroscience. Magnetic resonance imaging modalities (volumetric, diffusion tensor, spectroscopy, functional) have been as diverse as the populations studied (normal cognition to autism to dementia). Functional Magnetic Resonance Imaging (fMRI) studies investigate brain region activation by using the level of blood oxygenation to generate contrast. These studies often require an interdisciplinary team of neuroscientists, physicists and computer scientists. These studies are also very expensive and time consuming to complete. To make the most of this time and expense, an fMRI database would maximize knowledge gained from any one individual study. The purpose of this paper is to describe such a database and to show how investigators have used this database to create a novel experiment with pre-existing data.

Methods

I initially searched PubMed with the text words: “MRI AND brain AND database”. I found 380 articles. To focus my search, I searched the MeSH Database with “MRI” and identified the MeSH term “Magnetic Resonance Imaging.” I then restricted this MeSH term to major topics only and sent this term to the search box. I then searched “brain” and “databases” in the MeSH database. Both of these terms were MeSH terms, and I restricted them to major topics only and sent them to the search box with “and”.

None of their respective subheadings appeared relevant to my search. My search box read as follows: “Magnetic Resonance Imaging” [Majr] AND “Brain” [Majr] AND “Databases” [Majr]. I performed a PubMed search and found 20 articles. I then applied the following limits: “Links to full text”, “humans” and “English”. I found ten articles; many of these were relevant to my search topic. I then searched “related articles” to [1] and found 207 articles. Many of the articles reported on the success of an imaging database, the fMRIDC – www.fmridc.org [2]. Several investigators have used this database to generate new scientific studies. I searched the fMRI Data Center database for “default networks” and then searched PubMed Single Citation Matcher to find these original studies.

Results

The fMRI Data Center (fMRIDC) was established in the autumn of 1999 to provide a mechanism for sharing fMRI data [3]. The *Journal of Cognitive Neuroscience (JOCN)* (Vol. 12, Suppl. 2, 2000) devoted an entire issue to the inaugural datasets. *JOCN* now requires submission of all data to the fMRIDC as a requirement of publication. Initially, response from the scientific community was tempered, but *Science*, *Nature*, and the *Proceedings of the National Academy of Sciences (PNAS)* now all have the same database submission requirement [1]. The fMRIDC currently has 122 datasets that are available to scientists and to the general public. For quality control purposes, the fMRIDC only accepts data from peer-reviewed articles. The fMRIDC takes the additional step of examining the agreement between the submitted and published data [3]. The submitted data includes the MR scanner protocol, the subject information (de-identified), the scan session information, and the experimental protocol [4]. This extensive “multiple entrypoint" data allows users of the fMRIDC to manipulate existing data in novel ways [1]. To request the data, a potential user simply fills out a web form that sends an order notification to the fMRIDC. The user will then receive the information via CD or DAT media. In the future, imaging data may be available online [3]. The fMRIDC database can be used to train the next generation of neuroscientists, provide independent confirmation of existing data, and re-using existing data in novel ways to provide new information [1].

An example of the latter is a study published in the *PNAS* that examined default-mode network activity as a way of distinguishing Alzheimer's disease from healthy aging [5]. The default-mode network is the pattern of "functional connectivity" seen when the brain is in its resting state [6]. To investigate the default-mode network in the Alzheimer's disease population, Greicius used a study that was previously submitted to the fMRIDC [7]. The original study compared functional brain imaging in young, non-demented and demented older adults during a simple visual and motor task. Greicius applied a different statistical technique (independent component analysis) to one of his earlier datasets of young healthy controls as a proof of concept [8]. He then applied the same statistical paradigm to dataset from fMRIDC to show that default-network showed decreased resting state activity in the posterior cingulate and hippocampus in the Alzheimer's disease group. This suggested a potential etiology of previously reported PET studies showing hypometabolism in the posterior cingluate cortex in Alzheimer's disease [9].

Discussion

With little expense and no subject recruitment, Greicius used an existing imaging database to make an important contribution to the field of neuroscience. This example also illustrates the importance of the "multiple entrypoints" of data entry that allow users of the fMRIDC to approach raw imaging data with novel statistical analysis. The original article submitted to the fMRIDC [7] has been cited 83 times and was published in a journal with an impact factor of 5.197. The article that utilized this data from the fMRIDC [5] has already been cited 72 times and was published in a journal with an impact factor of 9.643. While both authors have contributed immensely to the field of neuroscience, the recycled data has arguably been more valuable than the original data. This example strongly argues for continued contributions to the fMRIDC so that future databases may evolve and contribute multiple times to the field of neuroscience.

Conclusion

Large-scale brain imaging studies cost a considerable amount of time and money. For any given fMRI dataset, the fMRIDC promises to maximize the contribution of any single study to the field of neuroscience. The fMRIDC is currently in the process of moving from Dartmouth College to UCSB. The Data Center is no longer accepting new datasets in preparation for the move, but they will continue to send out requested datasets in the interim [2]. The recent move highlights some of the difficulties in managing such a massive amount of data, which is approximately 2.6 terabytes [1]. Given the importance of such a database, funding and ease of access should be carefully protected for the next generation of neuroscientists.

[1] Van Horn JD, Grafton ST, Rockmore D, Gazzaniga MS. Sharing neuroimaging studies of human cognition. Nature neuroscience. 2004 May;7(5):473-81.
[2] Dartmouth. www.fmridc.org. fmridc [website] 2007 September 3, 2007 [cited 2007 September 3, 2007]; 2007:[fMRI database]. Available from:
[3] Van Horn JD, Grethe JS, Kostelec P, Woodward JB, Aslam JA, Rus D, et al. The Functional Magnetic Resonance Imaging Data Center (fMRIDC): the challenges and rewards of large-scale databasing of neuroimaging studies. Philosophical transactions of the Royal Society of London. 2001 Aug 29;356(1412):1323-39.
[4] Van Horn JD, Gazzaniga MS. Opinion: Databasing fMRI studies towards a 'discovery science' of brain function. Nature reviews. 2002 Apr;3(4):314-8.
[5] Greicius MD, Srivastava G, Reiss AL, Menon V. Default-mode network activity distinguishes Alzheimer's disease from healthy aging: evidence from functional MRI. Proceedings of the National Academy of Sciences of the United States of America. 2004 Mar 30;101(13):4637-42.
[6] Cordes D, Haughton VM, Arfanakis K, Carew JD, Turski PA, Moritz CH, et al. Frequencies contributing to functional connectivity in the cerebral cortex in "resting-state" data. Ajnr. 2001 Aug;22(7):1326-33.
[7] Buckner RL, Snyder AZ, Sanders AL, Raichle ME, Morris JC. Functional brain imaging of young, nondemented, and demented older adults. Journal of cognitive neuroscience. 2000;12 Suppl 2:24-34.
[8] Greicius MD, Krasnow B, Reiss AL, Menon V. Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. Proceedings of the National Academy of Sciences of the United States of America. 2003 Jan 7;100(1):253-8.
[9] Reiman EM, Chen K, Alexander GE, Caselli RJ, Bandy D, Osborne D, et al. Functional brain abnormalities in young adults at genetic risk for late-onset Alzheimer's dementia. Proceedings of the National Academy of Sciences of the United States of America. 2004 Jan 6;101(1):284-9.

CTSC Biomedical Informatics (BMI) Course

Research Literature Search #1

Clearly state your search question: Do MRI databases exist?

Attempt	Database	Dates	Controlled Vocabulary*	Subheadings (optional)	Limits	Inclusion Criteria	Comments	
1	PubMed	8/21	MRI AND brain AND database (plain text)	N/A	N/A	N/A	380 articles	
2	PubMed	8/21	MRI [Majr] AND brain [Majr] AND database [Majr]	N/A	N/A	N/A	20 articles	
3	PubMed	8/21	MRI [Majr] AND brain [Majr] AND database [Majr]	N/A	Full text, English, Humans	N/A	10 articles	
4	PubMed	8/21	From above search, Article [1], searched "related articles"	N/A	N/A	N/A	207 articles	
5								
6								
7								

* Some databases such a SciSearch use only keywords or author names

Include any "History" documentation with this table.

File: CTSC 2007 Project 1 Table

Search Narrative #1

Interested in the existence of MRI databases, I initially searched PubMed with the plain text words: “MRI AND brain AND database”. I found 380 articles. To narrow my search, I used the MeSH Database to find MRI. I restricted “Magnetic Resonance Imaging” to major topics only and sent this term to the search box. I then searched “brain” and “databases” in the MeSH database. These terms were both MeSH terms, and I restricted them to major topics only and sent them to the search box with “and”. None of the respective subheadings appeared relative to my search. My search box read as follows: “Magnetic Resonance Imaging” [Majr] AND “Brain” [Majr] AND “Databases” [Majr]. I then performed a PubMed search and found 20 articles. I further restricted my search by using the following limits: “Links to full text”, “humans” and “English”. I found ten articles; many of these were relevant to my search topic. I then searched “related articles” to [1] and found 207 articles. Several of these articles were relevant to my search question.

[1] Van Horn JD, Grafton ST, Rockmore D, Gazzaniga MS. Sharing neuroimaging studies of human cognition. Nature neuroscience. 2004 May;7(5):473-81.