

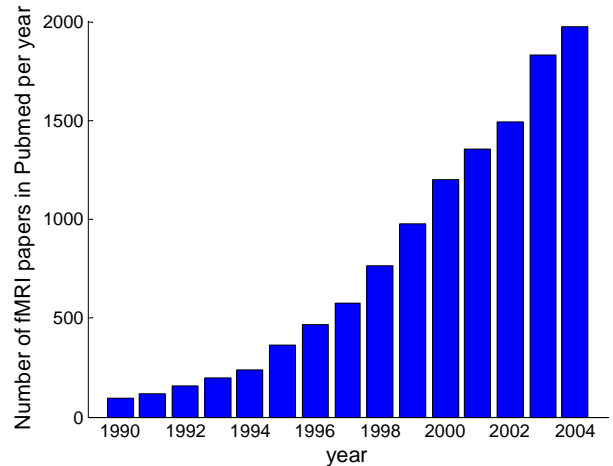
# AMAT: a meta-analysis toolbox

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released under GNU general public license

## Introduction

### What is AMAT?

AMAT is a matlab toolbox for meta-analysis of fMRI data. The number of fMRI papers examining cognitive functions is increasing far too fast for anyone to read them all, and with a variety of naming conventions for brain areas it is increasing difficult to obtain useful results from a general search data base like Pubmed. However, one common convention in fMRI papers is a results table which reports in a standard coordinate frame where activations were found in a particular task. AMAT just takes these tables and makes them searchable. This means that when you do your fMRI study and look at your results in SPM and thinks ‘what the hell does [-44 10 26] do?’ AMAT can give you an answer.



### How does it work?

Very simply. The core of AMAT is a big database which duplicates the results tables from hundreds of published papers and links them to a short description of the task and the paper's Pubmed ID number. AMAT is then able to look up pubmed to get the rest of the details of the paper (author, journal etc), so that when you search for a particular brain coordinate, AMAT can tell you which other papers have found results nearby.

### Some quick disclaimers

The information in the AMAT database is very minimal – just a coordinate, an area name and a description of the functional task in a couple of words. You might think this is not enough information, but this is deliberate. AMAT is not meant to replace careful reading original papers, it is just there to help you find which papers you should read. Keeping the database entries short also makes it easier to add to the database and to maintain it. AMAT is not meant to let you do detailed meta-analysis of the details of papers. For that you need an in depth database like the fMRI Data Centre at Dartmouth (<http://www.fmridc.org/>), which has far more information than AMAT can ever hope for.

### How do I use AMAT?

AMAT is a matlab toolbox which builds on many of the graphics functions used in SPM2, which is available from the good folks at the FIL in London. To use AMAT, you will need a working version of Matlab (6.5 or 7) and SPM2. Then download the AMAT files and start playing. Full installation and usage instructions are found below.

## **How do I add my papers to the AMAT database?**

I hoped you'd ask. It takes about 15 minutes to add each paper, less if you have the data in a favourable format (for example, if you are the author and have the word files). But that means it would take me almost 500 hours to add all the papers for 2004, which is time I don't really have. So if everyone who uses AMAT can add just one or two papers, the database will grow much faster. As soon as you add a paper, that data is available for you to search, so it really is worth your time – just 15 minutes. See page 8 for details.

## **Bugs, comments etc**

AMAT is currently a beta version, meaning that it is not exhaustively tested yet. I have used it on a Windows XP computer with Matlab 7.0 and a linux computer with Matlab 6.5 without any major problems, but I'm sure there are still bugs. When you find them, please let me know. Help, ideas, comments, suggestions and improvements are also welcome, just e-mail [antonia.hamilton@dartmouth.edu](mailto:antonia.hamilton@dartmouth.edu)

## **What does the A stand for?**

Well, it gets too confusing to have a program called MAT when you are working with matlab files all day, so the A is for A or Antonia's or Amazing or Awful or whatever you want.

## **Acknowledgements**

All of the graphics in AMAT are dependent on the graphics routines developed as part of spm2, so my thanks to the SPM developers for making their code freely available for people like me to hack.

## **Copyright**

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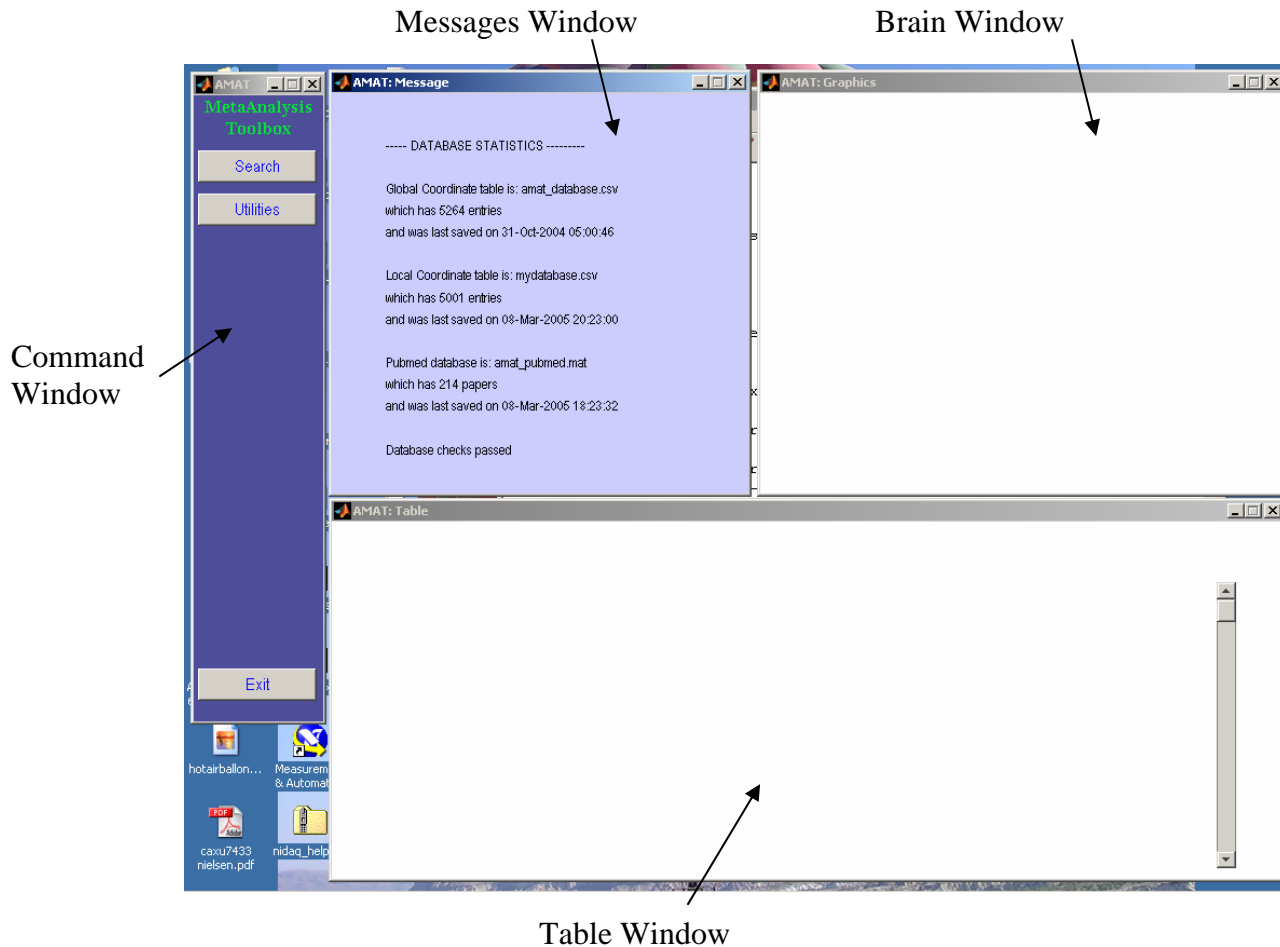
### How to install AMAT

1. You will need the basic functions for Matlab 6.5 or Matlab 7 installed on your computer, but you shouldn't need any extra toolboxes.
2. If you haven't already got it, download spm2 from the FIL ([www.fil.ion.ucl.ac.uk/spm](http://www.fil.ion.ucl.ac.uk/spm)) and install it. Make sure the paths are set up so that if you type **spm** at the matlab prompt, you get spm2.
3. Download amat.zip and amat\_databases.zip from ...
4. Create a folder called amat
5. Unzip all the files into that folder
6. In matlab, change directories into the amat folder
7. At the matlab command prompt, type **amat**

and that is it!

## How to use AMAT

When amat is installed and you are in the right directory, typing **amat** will open up 4 windows like this:



The **command window** is your menu bar – it lets you select the functions you want AMAT to do.

The **messages window** will start off telling you about the databases AMAT has loaded up. It will let you know if there is a database problem or if you need to get new information from Pubmed to update the database.

The **brain window** will be used to show you a sliced brain with the activation centres of the papers you are interested in

The **table window** will be used to show you the results of your searches in detail.

Click on the **search button** to see the search options. You can search for specific **papers** in the database, or you can search for the nearest **neighbours** nearest to a specific point in the brain.

To start with, try searching for **neighbours**.

AMAT will ask you for the **coordinates**, which must be 3 integers in the order x y z. You must indicate if these are MNI or Talairach coordinates. The default number of results to show is 30.

For this example, enter 44 15 0 as coordinates.

When you click **search**, the table window will list the database points nearest [44, 15, 0] in order of distance. Each point in the table is shown in red on the brain, and the search point is shown in green (or yellow).

**AMAT: Search Neighbours**

Enter the Search Terms

Coordinates:

Number of points:

☒ MNI ☐ Talairach

**AMAT: Graphics**

-45 14 0

**AMAT: Table**

Search Criteria = Nearest 30 neighbours to -44 15 0 (MNI)

Distance	X	Y	Z	Area	Descrip	Authors	Year	PMID
2.55	-46	14	0		discrete movement with rests - rhythmic movement	Schaal S Sternad D Osu R Kawato M	2004	15452580
3	-46	16	2	Left inferior frontal cortex	Decrease in obsessive-compulsive disorder	Hansen ES Hasselbalch S Law I Bolwig TG	2002	12057027
3.98	-40	16	1	Left insula	subtraction of single digit number > letter naming	Simon O Mangin JF Cohen L Le Bihan D	2002	11832233
4.45	-42	17	-4	Left inferior frontal gyrus	Evaluative judgment from visually sentences with	Zysset S Huber O Ferstl E von Cramon DY	2002	11906238
4.45	-42	17	-4	Left inferior frontal gyrus	Evaluative judgment from visually sentences with	Zysset S Huber O Ferstl E von Cramon DY	2002	11906238
4.45	-42	17	-4	Left BA 47	word memory encoding increase	Turk DJ Banfield JF Walling BR Heatherton TF	2004	15219600
4.45	-42	17	-4	Left inferior frontal cortex	self word memory encoding	Turk DJ Banfield JF Walling BR Heatherton TF	2004	15219600
4.49	-43	19	-2	L IFG	remember 6 of 3 letters from uninformative cue > rest	Zhang JX Feng CM Fox PT Gao JH Tan LH	2004	15488409
4.58	-48	16	2	Left inferior frontal cortex	Correlation with obsessive-compulsive	Hansen ES Hasselbalch S Law I Bolwig TG	2002	12057027
4.83	-43	17	4	Pars triangularis	tone discrimination	Muller RA Basho S	2004	15068915
5.87	-48	13	-3	left insula	pain self & other	Singer T Seymour B O'Doherty J Kaube	2004	14976305
5.92	-39	11	1	Antinsula	block transition	Konishi S Donaldson DI Buckner RL	2001	11162276
6.15	-39	15	4	inferior frontal gyrus	single subject action recognition	Hanzen F Rijntjes M Dettmers C Glauche	2003	12880794
6.75	-44	18	-6		discrete movement - rhythmic movement	Schaal S Sternad D Osu R Kawato M	2004	15452580
6.75	-44	18	-6		discrete movement with sound > rhythmic	Schaal S Sternad D Osu R Kawato M	2004	15452580
6.94	-38	15	4	Right inferior frontal	Viewing of dots in one of four displayed boxes	Casey BJ Cohen JD O'Craven K Davidson RJ	1998	9758739
7.27	-38	20	0	Insula	prepare to make finger mvmt. not initiation	Buccino G Vogt S Ritzl A Fink GR Zilles	2004	15091346
7.46	-51	18	-3	L lateral PFC	encoding activity in memory for structured v.	Bor D Curriming N Scott CE Owen AM	2004	15217392
7.63	-38	14	5	Left insula*	somatic hallucinations in schizophrenia	Shergill SS Cameron LA Brammer MJ Williams	2001	11606687
7.81	-49	14	8	inferior frontal gyrus	visual imagination	Bor D Curriming N Scott CE Owen AM	2004	15217392

Clicking on a line in the table will move the cursor to that point in the brain and bring up more information about the database entry in the messages window, see right.

It will also give you the option to see just the coordinates of that particular paper, just as if you had searched for the paper itself.

**AMAT: Message**

MNI Location: -46.5 14.5 -0.356

BA 47

----- Stimulus: -----

discrete movement with rests - rhythmic movement with rests

----- Paper: -----

Schaal S Sternad D Osu R Kawato M

Rhythmic arm movement is not discrete.

Nat Neurosci 2004

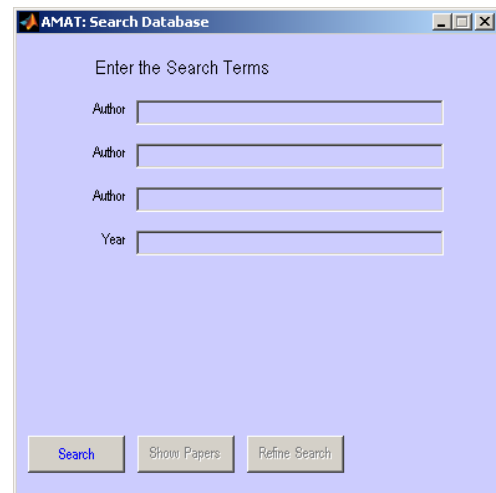
Now if you go back to the Menu bar and select the **papers** option, you can search for a particular paper. The message window will ask you to enter the search terms – up to three authors and a publication year are allowed.

Enter your terms and click **search**

AMAT will tell you how many papers it found so you can decide whether to look at them or to refine your search

When you click **show papers**, the AMAT table window will show the results of your search. The terms you used to search are listed at the top.

Clicking on a line in the table will display more information about that paper in the messages window, and will give you the option of seeing the database entries for one particular paper.



AMAT: Search Database

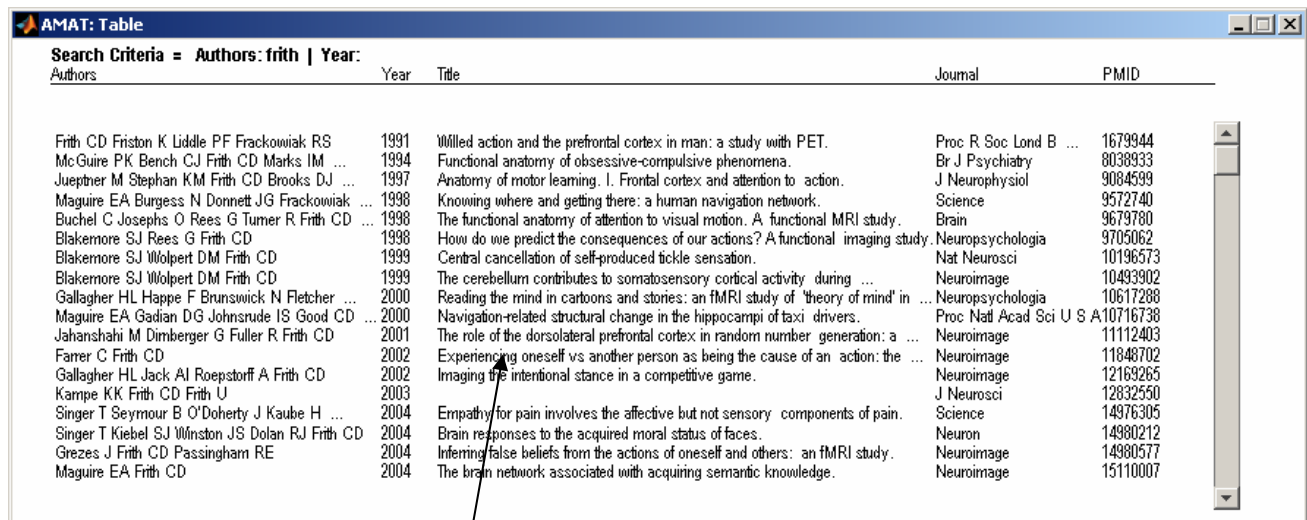
Enter the Search Terms

Author

Author

Author

Year



Search Criteria = Authors: frith | Year:

Authors	Year	Title	Journal	PMID
Frith CD Friston K Liddle PF Frackowiak RS	1991	Willed action and the prefrontal cortex in man: a study with PET.	Proc R Soc Lond B ...	1679944
McGuire PK Bench CJ Frith CD Marks IM ...	1994	Functional anatomy of obsessive-compulsive phenomena.	Br J Psychiatry	8038933
Jeupther M Stephan KM Frith CD Brooks DJ ...	1997	Anatomy of motor learning. I. Frontal cortex and attention to action.	J Neurophysiol	9084599
Maguire EA Burgess N Donnett JG Frackowiak ...	1998	Knowing where and getting there: a human navigation network.	Science	9572740
Buchel C Josephs O Rees G Turner R Frith CD ...	1998	The functional anatomy of attention to visual motion. A functional MRI study.	Brain	9679780
Blakemore SJ Rees G Frith CD	1998	How do we predict the consequences of our actions? A functional imaging study.	Neuropsychologia	9705062
Blakemore SJ Wolpert DM Frith CD	1999	Central cancellation of self-produced tickle sensation.	Nat Neurosci	10196373
Blakemore SJ Wolpert DM Frith CD	1999	The cerebellum contributes to somatosensory cortical activity during ...	Neuroimage	10493902
Gallagher HL Happe F Brunswick N Fletcher ...	2000	Reading the mind in cartoons and stories: an fMRI study of 'theory of mind' in ...	Neuropsychologia	10617288
Maguire EA Gadian DG Johnsrude IS Good CD ...	2000	Navigation-related structural change in the hippocampi of taxi drivers.	Proc Natl Acad Sci U S A	10716738
Jahanshahi M Dimberger G Fuller R Frith CD	2001	The role of the dorsolateral prefrontal cortex in random number generation: a ...	Neuroimage	11112403
Farrer C Frith CD	2002	Experiencing oneself vs another person as being the cause of an action: the ...	Neuroimage	11848702
Gallagher HL Jack AJ Roepstorff A Frith CD	2002	Imaging the intentional stance in a competitive game.	Neuroimage	12169265
Kampe KK Frith CD Frith U	2003	Empathy for pain involves the affective but not sensory components of pain.	J Neurosci	12832550
Singer T Seymour B O'Doherty J Kaube H ...	2004	Brain responses to the acquired moral status of faces.	Science	14976305
Singer T Kiehl SJ Winston JS Dolan RJ Frith CD	2004	Inferring false beliefs from the actions of oneself and others: an fMRI study.	Neuron	14980212
Grezes J Frith CD Passingham RE	2004	The brain network associated with acquiring semantic knowledge.	Neuroimage	14980577
Maguire EA Frith CD	2004			15110007

Click here  
to see this



AMAT: Message

----- Paper: -----

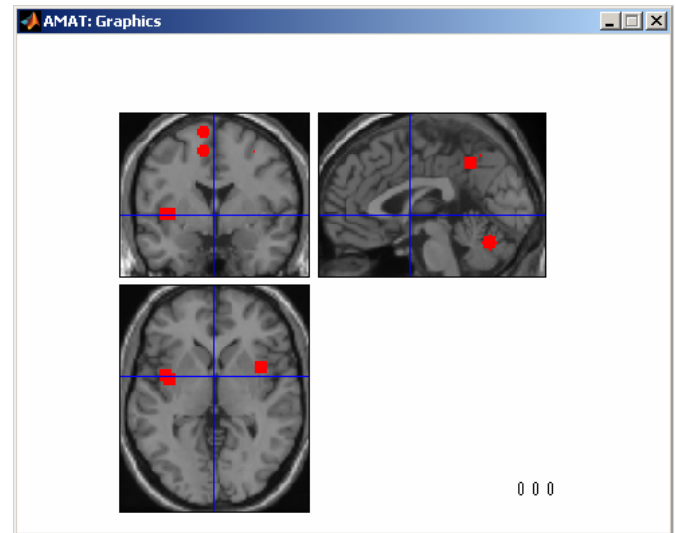
Farrer C Frith CD

Experiencing oneself vs another person as being the cause of an action: the neural correlates of the experience of agency.

Neuroimage 2002

So when you click **show coordinates of this paper**, the brain window will display the locations reported in the paper and the table window will list the coordinates and descriptions. Note the the red blobs in the brain window just mark the activation focus – AMAT does not have information on the number of voxels or significance of the original activation reported, and shows all activations at the same size.

Clicking on the table window will move the cursor in the brain to that location and update the message window to show the full description of an area.



You will now also have the option to search for the nearest neighbours of the current location, so you can see what else activated this area.

AMAT: Table

Search Criteria = Paper ID 11848702

Distance	X	Y	Z	Area	Descrip	Authors	Year	PMID
0	-40	2	2		joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	-8	-4	70	Left SMA	joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	-26	-10	62	Left lateral premotor area	joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	34	-32	44	Right primary sensorimotor cortex	joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	-46	-30	60	Left primary sensorimotor cortex	joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	0	-66	-22		joystick / computer control of cursor	Farrer C Frith CD	2002	11848702
0	-8	-4	54	Left SMA	"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	34	-6	54	Right lateral premotor cortex	"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	-24	-12	58	Left lateral premotor cortex	"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	-38	-26	54	Left primary sensorimotor cortex	"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	32	-30	42	Right primary sensorimotor cortex	"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	44	-32	48		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	-30	-44	54		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	18	-60	32		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	8	-68	-46		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	16	-56	-24		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	-22	-64	-26		"The subject moved a joystick but a cursor on ...	Farrer C Frith CD	2002	11848702
0	44	-58	32		The subject moved a joystick and a cursor on the ...	Farrer C Frith CD	2002	11848702
0	-48	-52	40		The subject moved a joystick and a cursor on the ...	Farrer C Frith CD	2002	11848702
n	c	68	60		The subject moved a joystick and a cursor on the ...	Farrer C Frith CD	2002	11848702

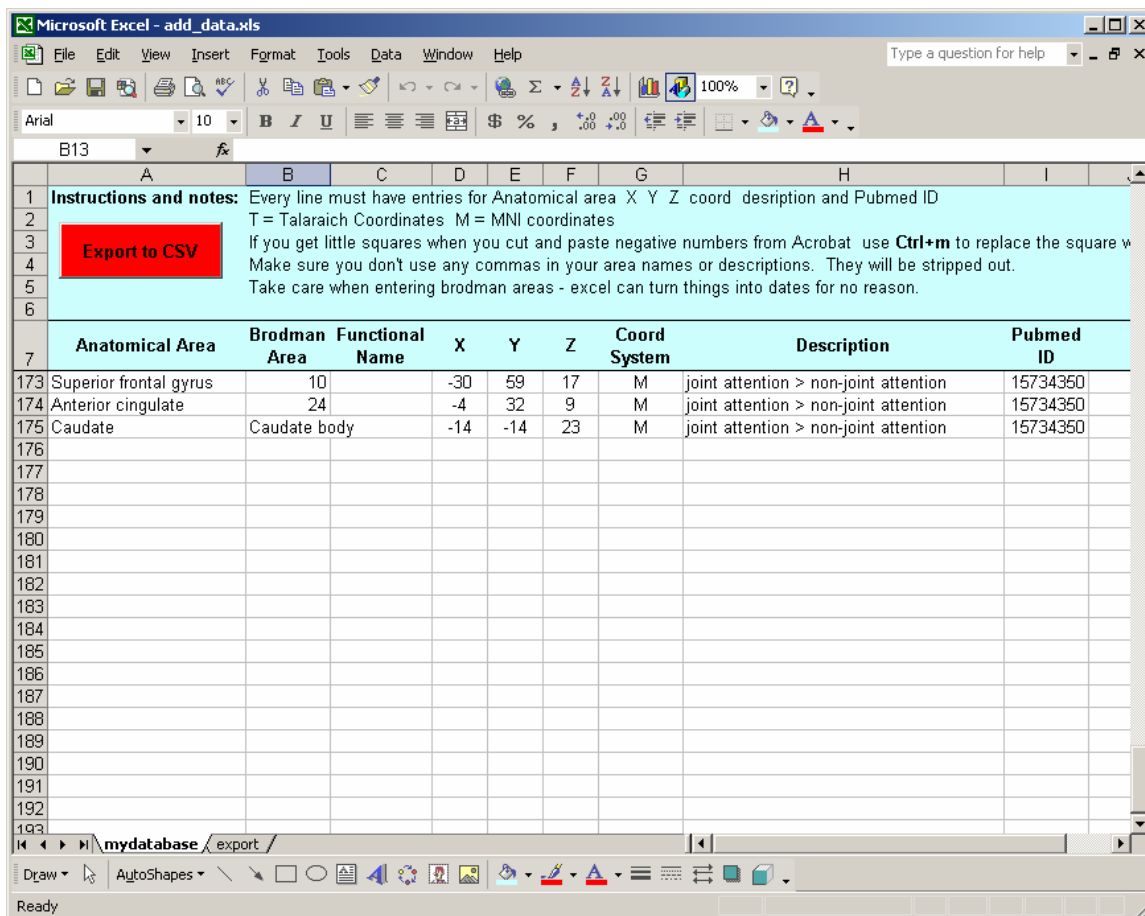
When you've played with AMAT a bit, you will find that you can alternate back and forth between searching for regions and searching for papers, tracking activation patterns through the brain. Which I think is quite fun.

When you are done, just click **Exit** on the menu bar to quit!

## Adding data and database management issues

These are the important but less fun bits about the workings of AMAT. The AMAT database is actually 3 files. The main database is **amat\_database.csv**, which contains the vast majority of the data. This is supplemented by **mydatabase.csv**, which is available for the user to add data without any risk of corrupting the core dataset or forgetting which data is new and which is old. My hope is that users will gradually add to their local **mydatabase.csv** and then send me the file when it has lots of entries so I can add it to the central database for other users. The third file is **amat\_pubmed.mat**, which is the file generated by AMAT when it contacts Pubmed to obtain information on the details of papers.

To make it easy to add data to your local **mydatabase.csv**, there is also an Excel file called **add\_data.xls** which looks like this. You will have to enable macros when you open the file for the export functions to work.



The column headings and notes are fairly self-explanatory – all you need to do is fill in some rows of data. Entries for Brodman Area and Functional name are optional but all the other columns should be completed, and don't leave any blank rows.

Most .pdf files will let you copy and paste data, often only one column at a time but that is still a lot quicker than typing. Addins for Adobe Acrobat like Jade from BCL



(<http://www.bcltechnologies.com/document/products/products.htm>) make it quicker and cleaner to copy and paste data. When you copy negative numbers from a pdf, Excel will sometimes show a square instead of a minus sign. To fix this, select the affected cell (only one at a time) and press Ctrl + m. You should get your minus back.

For each row, you will also need to enter an M if the coordinate system is MNI, T if it is Talaraich, a brief description of the task conditions and the pubmed ID.

The pubmed ID for a paper is the number labeled PMID below the abstract when you look for a paper on pubmed, and it provides a unique identifier for each paper. An example is shown on the right.

The screenshot shows the PubMed website interface. At the top, there are logos for NCBI, PubMed, and the National Library of Medicine. Below the logos, there are search bars and navigation tabs. The main content area displays a search result for a paper titled "Activation in posterior superior temporal sulcus parallels parameter inducing the percept of animacy." by Schultz J, Friston KJ, O'Doherty J, Wolpert DM, Frith CD. The PMID 15721247 is circled in red. The abstract text is visible below the title.

When you have entered a paper or two of data (or more) into Excel, click the red **Export** button. A macro will export all the data to **mydatabase.csv** for matlab to read, and will save your **add\_data.xls** too. If it prompts you to overwrite the current files, you should accept.

Now you need to make your new data accessible to AMAT. If AMAT is open, restart it, otherwise just start it up. The database statistics should show additional entries in the local database and remind you to update the pubmed database. Click **Utilites - Update database**, and AMAT will connect to pubmed to obtain the author and journal information on the new data. You will have to be running matlab from a computer with an internet connection which matlab is able to use for this to work. If you have problems, type **help urlread** at the matlab prompt for more information.

Once the database has been updated, AMAT is ready to go and you can explore your new data! When your local database has more than 500 lines, please e-mail it to me so I can add it to the central AMAT database for everyone to use. Similarly, if you check the AMAT website occasionally you will find updated databases to download.

Note: For people who hate Excel, it is possible to add lines to **mydatabase.csv** using any other text / data editor you want. I just use Excel as an example because most people are familiar with it.

The screenshot shows the AMAT MetaAnalysis Toolbox interface. It has a blue background with a vertical list of buttons on the right side. The buttons are: Search, Utilities, Rebuild Database, Update Database (highlighted with a red arrow), Database Stats, Reload database, and Exit.