Science AMA Series: We are the neuroscientists who started the Open Neuroimaging Lab, a winner of the Open Science Prize - AMA

Open$_N$*euroimaging*[1]*andr*/*ScienceAMAs*[1]

[1]Affiliation not available

April 17, 2023

Abstract

At its vibrant frontier, neuroscience is becoming the playground of a worldwide interdisciplinary community which our team reflects well: we come from 4 different continents and diverse backgrounds. Roberto, Katja and Satra met at a BrainHack unconference, an event of art, science, and sleepless nights. Later, Katja met Amy in a conference on arts and neuroscience, and at MIT, a neurotechnology class linked Amy, Satra and eventually Roberto. We share a passion for open science and collaboration, a keen interest in neuroanatomy and visualization, and a drive to engage humanity in understanding ourselves better in health and in disease. Amy, through Eyewire, is allowing thousands of people to map the brain through games and Roberto has been pleading all of us around him to work on crowdsourced solutions for brain imaging. The Open Science Prize competition offered the opportunity to mesh these interests and to hopefully attract a worldwide community. The Open Neuroimaging Laboratory (http://openneu.ro/start/) is a project to facilitate finding, improving, and reusing the massive amount of brain MRI data available online. This data represents an enormous funding effort and the work and goodwill of thousands of participants. BrainBox, our first application, transforms these static MRIs into "living" matter for collaborative curation and analysis using only a Web browser; and MetaSearch, our second app, allows it to easily query this huge, living resource and find data relevant to you. Users can work, discuss, edit and annotate MRI images simultaneously. No data are downloaded, no software installed, allowing users to incrementally improve each other's work. This increases scientific efficiency, improves public data quality, and reduces redundant effort. We already index more than 8000 MRIs, which are ready for collaborative projects. Twitter: https://twitter.com/OpenNeuro Facebook: https://www.facebook.com/openneuro/ You can vote for Open Neuroimaging Lab to win Phase II funding from the Open Science Prize (NIH, Wellcome Trust) here: http://bit.ly/openneurolab We will be back at 1 pm ET to answer your questions, ask us anything! Roberto Toro (Institute Pasteur, France): I am interested on the development and evolution of the brain, which I study through mathematical modelling, magnetic resonance imaging and genetics. https://twitter.com/R3RT0 Katja Heuer (Max Planck Institute, Germany): I am genuinely curious about brain development. I am studying the development of the human brain and its connectivity using magnetic resonance imaging. My aim is to relate brain development and language performance. https://twitter.com/katjaQheuer Satrajit Ghosh (MIT, joins at 2 pm ET): My research interests span computer science and neuroimaging, specifically in the areas of applied machine learning, software engineering, and applications of neuroimaging. The primary focus of my research group is to develop knowledge discovery platforms by integrating a set of multidisciplinary projects that span precision medicine in mental health, imaging genetics, machine learning, and dataflow systems for reproducible research. https://twitter.com/satra_ Amy Robinson Sterling (Princeton University): I am passionate about understanding consciousness and human elements like creativity and curiosity. I'm the Executive Director of Eyewire, a game to map the brain played by a quarter million people worldwide. I hope that by bringing together curious people from different backgrounds we will bring new perspectives to old neuroscientific challenges. https://twitter.com/amyleesterling

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Twitter: https://twitter.com/OpenNeuro Facebook: https://www.facebook.com/openneuro/

You can vote for Open Neuroimaging Lab to win Phase II funding from the Open Science Prize (NIH, Wellcome Trust) here: http://bit.ly/openneurolab

We will be back at 1 pm ET to answer your questions, ask us anything!

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Satrajit Ghosh (MIT, joins at 2 pm ET): My research interests span computer science and neuroimaging, specifically in the areas of applied machine learning, software engineering, and applications of neuroimaging. The primary focus of my research group is to develop knowledge discovery platforms by integrating a set of multidisciplinary projects that span precision medicine in mental health, imaging genetics, machine learning, and dataflow systems for reproducible research. https://twitter.com/satra_

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READ REVIEWS

Hi guys,

WRITE A REVIEW

CORRESPONDENCE:

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So my question is; have neuroscientists been able to identify any distinctive changes in brains of people suffering from mental illnesses, compared to healthy individuals? I'm specifically interested in things like generalized anxiety, OCD or depression. Thank you!

hhebee

There have been numerous studies of varying numbers of participants that have reported differences between groups of individuals with specific mental illnesses (this is, for example, a paper that looked at morphometric properties across many datasets including those we used in the ONL http://www.pnas.org/content/113/39/E5749.full). However, the situation is far from ideal. Thomas Insel, who was director of the National Institute of Mental Health for many years, often compared the little progress in mental health with the incredible progress made in some other areas of biomedical research (his TED Talk is very enlightening: http://www.ted.com/talks/thomas_insel_toward_a_new_understanding_of_mental_illness). He criticised the traditional framework of neuroscience for not being adapted to the “surreal complexity” of the human brain. One of the solutions that T. Insel proposed was data sharing. Our ONL project aims at going a step further, making the shared data directly accessible in the web. Many of the studies trying to link mental disorders and the brain are lamentably underpowered (they study groups of subjects which are too small to capture the natural diversity of the brain), and biased. Publication bias, p-hacking, cherry picking, the file-drawer effect, are some of the issues that plague biomedical research, and neuroimaging is one of its victims (read “Power failure: why small sample size undermines the reliability of neuroscience”). By facilitating researchers to collaborate together on a common resource – like the wikipedia – we aim at proposing a way of working that should help solve these problems.

For ADHD, BrainBox and MetaSearch currently index almost 1000 brains from the ADHD200 initiative (http://brainbox.pasteur.fr/project/adhd200). You can help ADHD research by participating in the curation of these data, tagging, for example, the brain MRIs with motion (not unexpected in the case of ADHD…), or segmentation errors. Some of this curation requires a certain degree of neuroanatomical expertise, but we hope to set up tutorials that will help citizen scientists get started.

I have an MRI of my own brain from a few years ago. How can i contribute? I asked the radiologist if i could have the pics and he gave me a CD with software included where i could explore all the data (which blew my mind).

sivadneb

If you are OK uploading your brain to DropBox, you could paste the “shared” link into BrainBox and start viewing and annotating your brain in less than 5 minutes!! You can also make it part of a private project, to share it with friends/collaborators. DropBox, however, is not a permanent repository for data. If you really want to contribute to research, it would be better to contact a neuroscience group and propose to participate in a project. Make sure to ask to the researchers what’s their policy relative to data sharing!!

No question here; just wanted to say thank you for all the hard work, passion and dedication that comes with being so incredible!

JessTheGardener

Thank you for the kind words! Greatly appreciated :)

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redditWinnower

Excellent! Love that the future of science includes Reddit.

Can neuroimaging be used to reliably detect and classify forms of dementia in its different stages? As someone whose family has a history of the disease, I'm curious on a personal level. I've always been told that an autopsy was the only sure way to tell for sure which wouldn't be useful to the living.

Regardless if you answer this or not, I appreciate your time doing the AMA.

Tcloud

Lots of research in this direction, but not reliable detection of dementia from MRI yet. A recent paper (Mert: http://www.pnas.org/content/113/39/E5749.full) suggests that neuroimaging data contains enough information to detect it, but we still do not know how to mine this information. Stronger collaborative efforts and data sharing should allow us to make progress faster.

Another effort (http://dx.doi.org/10.1016/j.jalz.2016.02.006) ran a crowd-sourced effort to try and generative predictive markers of cognitive decline, but failed to identify a meaningful predictor. Failure does not necessarily mean there is no information in the data. It supports the need for diverse approaches and larger observations of variance in the disease.

What are the weakest points in your area and how do you plan to deal with them?

ezzyrd

→ Redundant effort: Need to allow incremental work?

→ falsifiability: Neuroscience could benefit from a stronger effort to develop mathematical/theoretical models, that could be tested and falsified.

→ Lack of reproducibility: Fostering collaboration and data reuse

→ Limited open data: A lot more data are being handed over to Google, Amazon, and Facebook than is made available for science whether by individuals or scientists.

Creating better open tools with clear UI/UX should help address these challenges.

What advice would you give to someone who is thinking about doing neuroscience in their honours year of university? General tips, areas of reading, motivational advice?

cunnyfunt103

→ Try to do an internship in a laboratory with a clear engagement in Open Science and Reproducible Research! Researchers interested in a more open and collaborative research are often more present in social media such as twitter or reddit. That may be a good place to start making contacts.

→ If you like writing, consider starting or contributing to a blog to share cool science that you encounter at university but which might be new and novel to most people. At Eyewire, some of our more popular blogs and social media posts have been written by undergrad interns. Any kind of published writing is a good addition to the resume.

→ Also there are many open science projects in neuroscience like the ONL that one can contribute to.

→ If you're a developer, consider contributing to one of the many open source projects on GitHub

Thanks for the AMA! Your field is at the intersection of two of my lay/hobbyist interests: machine learning and neuroscience.

What types of inferences do you expect Machine Learning to be able to derive from different imaging techniques (CT vs MRI vs fMRI vs PET etc.)?

Are you training your ML networks to interpolate several imaging modalities of the same subject to produce results? If so, how do you incorporate these different modalities? Do you run subnetworks on each modality first and pipe the results into another network? Or do you supply all modalities into the same input layer and let the network self-organize as it trains?

Thanks again for sharing your interesting work with us!

eudaimondaimon

Thanks!

People are using ML to do various things in neuroimaging. Some of it is focused on diagnosing disorders, some on predicting treatment outcome, and some to understand brain - behavior relationships. It is a very active area. Here is an example of multimodal work (http://biorxiv.org/content/early/2016/11/07/085506). Some people are approaching it more from a computational modeling standpoint and using layers to construct hierarchies in certain brain systems. Some of the machine learning in mental health is not even on images. For example, text (http://dx.doi.org/10.1371/journal.pone.0168224), voice (http://sspnet.eu/avec2016/), and typing (http://www.popsci.com/type-test-diagnose-parkinsons). For the open neuroimaging laboratory there is no machine learning used for the current prototypes.

Hello! I'm so excited to read your answers to this AMA!

I'm currently finishing up my last semester of undergrad as a neuroscience major. Since getting a Bachelor's in neuroscience is a little out of the ordinary, I'm having trouble determining my next step from here. I've already decided to take the year off to explore some research opportunities (which are still up in the air as grants haven't been provided yet). However, there are so many higher education options from here and I have no idea where to start. I'm interested in adolescent brain development, specifically how stress affects development and what factors may be predisposing teens to depression in later adulthood.

Most of my advisers have recommended the clinical psychology route, but I'm not too sure that's appropriate for me. I'm interested in learning about the path you guys took for your education to get you where you are now. You are an inspiration to me!

dollyhepatie

Try to fit several internships into your year and explore all options that you think could be interesting! Most often, while exploring the first option, you will stumble over so many other interesting possibilities

automatically, which will just all naturally build the future steps of your path! If you think, clinical research is not your preference, start in a lab doing basic research, and see if you want more of a clinical or applied component. You can either apply for suggested internship projects – or: It is often even possible to suggest your own research project! If you are interested in a special topic, and have an idea based on the literature you read, you can find a lab with similar interests and often they are open minded and happy to have and support people with fresh ideas. And from there on they can help you explore and find directions you might love.

To my understanding, these are anatomical MRI scans. In other words, they are static snapshots of subjects' brains.

Absent of any connection with behavior, what kinds of science questions do you think these data will bear on, and do you have any specific examples or past successes in mind?

twohundred1

Brain anatomy is not fixed nor static. The shape and texture of the brain is constantly changing, with development, maturation, experience and disease. Researchers have been even able to observe changes in brain anatomy at the scale of a few hours!

Many of the data sets that have been currently indexed in BrainBox and MetaSearch (the tools we have built for the ONL) contain hundreds of behavioural/cognitive variables that could allow us to link brain anatomy and cognition. Furthermore, a few of these data sets also contain longitudinal data (that is, scans of the same individual at different times). The examples of links between anatomy and cognition are numerous. There is, for example, a well replicated link between brain volume and IQ (a correlation of just ~0.2 but very reproducible), and also links between linguistic performance and the anatomy of the “planum temporale” (a region in the temporal lobe where the higher order auditory areas are located)

For an academic neuroscientist trying to get work published, how can/should dedication to Open Data be incentivized? As you all know, junior scientists are often struggling to keep up with their workloads in the first place, so how do you suggest they (we) get motivated to put in the extra effort to share data in an accessible form? It takes a lot of time to get files organized in a way that other people would understand--why should we do it?

Thanks for the AMA!

TemporalParietal

The traditional framework of neuroscience is slowly changing into a more open type of research. It is true that for the moment open science requires an extra amount of work that is not properly rewarded. We ourselves face this problem, and most of the work that we are doing for our Open Neuroimaging Laboratory has been done out of sheer passion, and because we think this is the way in which our science should really work and progress. That said, there is a growing awareness on the need for open science. The website http://whyopenresearch.org/ compiles a good set of reasons for open science, as well as a list of funding opportunities exclusively available to researchers engaged in open research. We have to thank the Open Science Prize (NIH, Wellcome Trust and HHMI) for giving us the opportunity to develop our Open Science project!

Doing a Masters Degree and currently looking for PhD positions... Im wondering in your opinion(s), how important is institution "fame" in choosing a PhD to apply to? I know that love of the project is

important, but I can't help but feel that the institution can make a higher impact if it is more famous - due to superior facilities and collaborations etc.... I would appreciate any advice on this.

Thanks a lot!

Bogger92

Institutional "fame" matters, but not as much as doing impactful science. After all, famous institutions are only so because passionate scientists successfully pursue important questions on their campuses. Breakthroughs can happen anywhere :) My advice is to go with your deep curiosities and you'll end up in the right spot. -Amy

Hi guys!

To whomever wants to answer, a question about synaptic plasticity: backpropagation is seemingly not how the brain learns, generally speaking. However, the mechanisms for synaptic plasticity that I know about (Short/Long-term Potentiation/Depression, STDP, etc...) are AFAIK not very useful when we try to implement them in silico (Machine learning).

How far do you think we are from finding a mechanism, not necessarily similar but surely inspired by brain plasticity, for training spiking neurons to solve machine learning tasks efficiently?

And a more lighthearted question, to each one of you: What's an interesting/fun fact about the brain that you recently learned?

Thanks for doing this AMA!

Chronolitus

Pardon that we're answering the fun question :)

Satra: serious fact - the brain may not be operating under a single genome hypothesis (http://science.sciencemag.org/content/354/6312/557.full) fun fact - the brain of the bottlenose dolphin is super intricate (http://brainbox.pasteur.fr/mri?url=http://braincatalogue.org/data/Bottlenose_dolphin/MRI-n4.nii.gz&view=sag&slice=334) !

- Valentino Braitenberg in his book ‘Gehirngespinste’ draws a nice picture to describe the impressive amount of nerve fibers in a human brain. A single human brain has as many fiber connections as to reach to the moon and back! If you take all fiber connections from all living human brains, they would reach out deep into the sky of fixed stars, about 100 light years.
- Only mammals born with a placenta have a corpus callosum (the main fibre tract connecting the right and left hemispheres). Marsupials like kangaroos or wallabies do not have a corpus callosum (their right and left hemispheres are connected through other, smaller bundles) If you manage to make connections from the visual cortex to innervate the auditory cortex of a ferret, its auditory cortex will develop into something that looks very much like visual cortex. And the animals behave as if they were able to see! (with their auditory cortex!)
- There is a single law that relates the amount of cortical surface area and brain volume that links all vertebrates, from mice and shrews, up to the whales. That makes me feel a strong connection with all my mammalian cousins :D. There’s a popular question among cognitive scientists about “what it’s like to be a bat”. Laws like this one make me feel that answering “Like me” will not be too wrong.

Hi Folks,

I'm a big fan of open science and citizen science. I took a look at your autism project and feel like it really needs more of a primer. Are we supposed to be labeling specific brain areas with colors? Is that being done by machine algorithm? I ask this as MD and even though radiology isn't my field, I've looked at a lot of MRIs and even given that background the purpose of the project wasn't particularly clear. Additionally, how are these weighted? What are the primary study goals? I've worked and published in autism and developmental disability so I'm very interested in this.... I just don't feel like it's explained very well how a layman (hell, even an MD) can contribute.

Please enlighten me. (Also the file's seem pretty low res, is this compression to keep the project viable with bandwidth restrictions? I know high res imagining sets eat up terabytes of data)

designer_of_drugs

At the moment, BrainBox makes it very easy for you to find such projects as the one on Autism and the associated structural brain scans. This rich dataset has been collected with large efforts of scientists and participants. An automatic algorithm has created a first segmentation into 48 regions (FreeSurfer result). It's true that for the moment there's not enough information, and it's because our focus has been currently into making the data available. However, there's an ongoing project to organise a "hackathon" where researchers interested in autism -- instead of working each of them separately -- could join efforts to produce a community-curated, manually-fixed version of the ABIDE dataset. The ABIDE hackathon should be one of the projects of the Brainhack-Global that is being prepared for next march. Stay tuned and check http://brainhack.org/ (at the Open Neuroimaging Laboratory we are big fans of BrainHack, and if you come you'll certainly meet some of us there). That said, if you have some neuroanatomical/neuroimaging expertise there are a few things where you could help: As you can see by scrolling through the slices, it has not been perfect in all places but requires human manual interventions to fix these automatically generated masks. And this is where you can now easily jump in, take the BrainBox pen or eraser, and help the community to get good masks at large scale. Doing this online, you share your work, time and effort with all research labs, which can then download the masks for their subsequent analyses to tackle their research questions (frequent issues are: meninges or parts of the eyeballs labelled as neocortex, missing temporal poles, missing cerebellum) The resolution is not changed but you see the data in its available original resolution. Most of the currently indexed human data comes from 1.5 Tesla and 3 Tesla scanners and ranges around resolutions of about $1mm^{3.}$ The resolution is the native one, it has not been downsampled.

What advice do you have for a struggling college student?

chessdolphin

Find what you're passionate about and start getting involved in it.

This may take some soul searching, a lot of writing, a lot of caffeine ha, but once you figure out what ideas matter to you, you're in a better position to find others that share your enthusiasm and to build a community, a network of people who you can build ideas with.

I'm a big proponent of starting side projects! Volunteer, work on things you care about - ignore money, it comes later. What matters is that you figure out how to take action on your ideas.

I wrote this article a while back for Elite Daily that may have some good tips :)
http://elitedaily.com/life/3-lifehack-habits/1183940/

Also - work hard. Like, really hard. Passionate, determined people rule the world.

Amy

Hey guys, thanks for the AMA

Are you guys leveraging the use of big data frameworks, libraries, etc for the analysis of your data? If yes, can you explain how you are doing that?

yuppienet

We do leverage a lot of different software for these projects and our research. They range from specialized tools for neuroimaging (e.g., AFNI, FreeSurfer, FSL, Nipy, SPM), workflow engines (e.g., AA, Nipype, CBRAIN), brain databases (e.g., COINS, LORIS, XNAT/Human Connectome Project, NIMH data archives), but also generic datastores (e.g., AWS, Dataverse, Dropbox, Figshare, Open Science Framework, Zenodo) and general purpose software (e.g., JavaScript, Python, R), and specialized scientific libraries (scikit-learn/image, tensorflow, etc.,.). The best is to try and get involved with many of the open projects in neuroimaging (nipy.org, fcp-indi.github.io, etc.,.). A goal of this platform is to make as much data as easily accessible to all.

First off... your work is utterly amazing. It's incredible to me when something reads like science fiction but no... it's really happening.

My question to you is this. What has surprised you in your work? What neuron did you flip over and think "well that's odd..."

BiggerBangTheory

I have to admit that I was initially very surprised when I started to realise that many neuroscience results that I took for granted were actually not that clearly established. “That’s odd” was my first reaction...

It was also so nice to see how many neuroscientists and labs are happy to make their data available if it’s easy for them.

Hello! Thank you so much for having this. I am a high school student very interested in studying neuroscience! My dream school is Mcgill University. Any other schools I should look at for top notch neuroscience research and education?

clairelise327

We're obviously partial to MIT, Princeton, Max Planck Institute and Institute Pasteur.. but these days there are many exceptional programs in neuroscience!

What are the best resources for completely new beginners to learn about your field?

TriedToShart

There are a ton of great brain YouTube videos out there!

Check out these TEDTalks on the brain: https://www.ted.com/topics/brain

Crash Course. Their physiology set has a bunch of nervous system videos: https://www.youtube.com/playlist?list=PL8dPuuaLjXtOAKed_MxxWBNaPno5h3Zs8

BrainCraft is a great series from PBS Digital Studios all about, you guessed it, the brain: https://www.youtube.com/user/braincraftvideo

It's Okay to be Smart occasionally has psychology videos: https://www.youtube.com/user/itsokaytobesmart

What are the limits of neuroimaging? Can we image to the synapse level maybe including the number and type of transmitters and receptors? That would be, in effect, a save state for a brain that maybe reconstructible with technology of the future.

pnasmaster

In-vivo imaging of the human brain is still at a rather coarse level. Technological advances have pushed resolution of structural MR images to submillimeter scale and it is quite amazing to see that it's possible to see some cortical layers. However, the brain is one of the most complex structures. To save the state of the brain, one would need to capture and preserve the entire structure. Currently the retinal neuronal patch (350×300×60 cubic microns) in eyewire alone use up (20 TB) of data. However, the structures themselves change over time, so preserving brain state for future reconstruction is in the realm of science fiction at the moment.

In addition to magnetic resonance neuroimaging, there's currently an explosion of cell-resolution neuroimaging being done. The BigBrain is a single human brain that has been sliced in more than 7400 slices each of which is being scanned at a resolution of 1 micron. New methods such as Polarised Light Imaging allow neuroscientists to scan whole human brain slices all while distinguish axonal fibres individually. One of the projects that we have proposed to the Open Science Prize if our Open Neuroimaging Laboratory is selected for Phase 2 is to integrate this type of data into our framework. You can see one BigBrain slice and a slice of the brain of a Vervet monkey in our tool MicroDraw here: http://microdraw.pasteur.fr/microdraw.html?source=/bigbrain/bigbrain.json http://microdraw.pasteur.fr/microdraw.html?source=/vervet/vervet.json Make sure that you zoom in! You'll be amazed!!

What are you most excited about when it comes to the future of neuroscience and machine learning?

Chispy

I'm most excited about automated, highly-accurate data analysis that enables us to rapidly map large volumes of brains. Historically, ensuring accurate analysis has been a huge hurdle to the pursuit of important scientific questions. Advances in machine learning are already starting to change that.

There is a lot of work going on in brain imaging and machine learning. We have used imaging to create models predicting treatment outcome in social anxiety disorder and depression. However, some of the most exciting areas to me are in machine learning and mental health that uses non-imaging behavioral information, things that can be acquired using a smartphone. For example, text (http://dx.doi.org/10.1371/journal.pone.0168224), voice (http://sspnet.eu/avec2016/;), and typing (http://www.popsci.com/type-test-diagnose-parkinsons). At the end of the day, to truly understand the brain, it's really going to be important to synthesize these information into computational models. But for the moment, some of these areas of ML and neuroscience are practically useful to target precision/personalized medicine.

There is a big need for data to apply some of these techniques. So some of our research has invested in open frameworks for mobile data collection. For example, we are developing a cordova/ionic based framework here (https://github.com/satra/MIT-VoiceUp-App), and initial applications have been deployed for data collection targeted at depression (android: https://play.google.com/store/apps/details?id=edu.mit.voiceup, ios: https://itunes.apple.com/us/app/mit-voice-up/id1160735265?ls=1&mt=8). We like open frameworks!! Please help contribute; whether code

or data :) !

Super interesting stuff! A few questions about your project:

1) How do you account for multiple scans from the same individual biasing the result of a study drawing from your database?

2) Are you concerned that scans from your database might be 'cherry-picked' to produce an optimal result? How do you ensure scientific integrity among those who use your site?

3) Will the ONL be used only for studies comparing differential anatomy, or could cognitive work be done with functional scans or lesion method?

AmbitiousPeach

1. For the moment our aim is to start by providing easy access to the data. It should be possible to check (for example by aligning brains and computing their mutual information or correlation) how similar they are. Not all these very similar brains will be duplicates, because there are subjects that are very similar because they actually belong to the same person that has been scanned several times (to test the effect of different scanning parameters, or to study the changes in brain anatomy after an experiment)

2. Since it is an open database where everything from raw data to the process of curating and annotating it to the results is shared, we hoped to increase transparency. The worst is when you see a plot with a few points and you are unable to guess whether there were more or not (cherry picking…). This should be less of an issue if we had access to all the data, as our tools BrainBox and MetaSearch make possible.

3. Currently, BrainBox focuses on the segmentation of structural MRI data. Maybe one thing that might be interesting could be to index and edit brainmasks which are used in functional MRI studies. Also, MetaSearch can grow to index other types of data, as the cognitive data.