# Standardizing neuroimaging atlas formats

## Introduction

Brain atlases are widely used in brain imaging to associate a structural or functional label with a position in a coordinate system, often defined within a brain reference space such as the MNI 305. Atlases are typically composed of a series of images, or a single parcellated image of a typical or averaged brain. They utilise either hard labels (zero, one, or several labels for a given position), or probabilistic information indicating the likelihood of a label. Atlases exist for both 3D and surface geometry and can represent various types of information (e.g. cytoarchitectonic or anatomical macroscopic sulco-gyral information, functional information, etc). While most researchers in neuroimaging will use one or several brain atlases in their analyses, the meta data and data format of these atlases vary. This implies that custom code will be written to extract the information and comparison of analyses will be harder to conduct. For example, the Harvard-Oxford (HO), Automatic Anatomical Labelling (AAL), Freesurfer labels, and JuBrain labels are amongst the most used atlases and do not represent their respective metadata or data in a consistent manner. There is also a growing number of functional parcellations and atlases of functional networks.

While atlases are ubiquitous and growing in number, there is no standard way of describing the information they contain, even for very similar types of atlases such as the HO and AAL. This is inefficient for developers and error prone, making the combination of atlases difficult and preventing easy experimentation and comparison. More broadly, the absence of a clear description and format makes the concept of what is an atlas (versus a template or a coordinate system) unclear.

## Methods

The definition of a new standard raises both technical and sociological issues. We capitalised on the International Neuroinformatics Coordinating Facility neuroimaging data sharing and atlasing programs, and gathered a group of researchers with competencies and experience in human brain atlases.

To constitute the working group, we reached out to the main neuroimaging software developers and to large projects such as the Allen Institute for Brain Science and the Human Connectome Project, as well as to neuroanatomists to obtain a good representation of both the developers of tools and the neuroscience community. This multi-pronged approach seems to have worked extremely well by bringing together the producers and the distributors of atlases within the community.

We met in person at the MNI in Montreal to first establish the specifications and use cases of this new format, and later at MIT with remote video connections to collaborators who were unable to attend personally. Over the course of those few days, we were able to create a new atlas standard format and several use-case examples of atlases following this specification. We used collaborative development tools such as Google documents and GitHub to further discuss and improve these specifications and to develop a first implementation of the format for five atlases : HO, AAL, an adult mouse and a mouse development atlas, and the neuromorphic atlas.

## Results

Our first proposal is described with five JSON examples at <https://github.com/INCF/HAWG-examples>. To ease the adoption of the format, we separated the metadata level information (the description of structures, the labels, etc) from the low level information – the image format. In every case, our group opted for simplicity in implementation, both to ease adoption and to reduce confusion. We converged on using JSON to encode this high level information, which will contain the description of the image files (NIFTI or other). While we recommend using NIFTI because it is widely used, other formats could possibly be used but may not be easily read by all applications. We use labels and tags that provide a more general framework than hierarchical structures. We also chose not to impose specific ontologies at this stage, although a recommended set of terms / ontologies may be proposed in the future. Importantly, the atlas specification is not specific to human brains, and has been written generically to contain support for any species or organ. Already some validation tools are emerging for this format - <https://github.com/stity/atlas-schema>.

Our next phase will be to reach out to the whole community for feedback and discussion before releasing the image format, and to propose reference implementations in current neuroimaging software (SPM, FSL,AFNI FreeSurfer, MINC, MRIcro, Allen Institute Brain tools, and others).

## Conclusion

The International Neuroinformatics Coordinating Facility supports the creation and funding of working groups and helps organize these standardization projects. This was necessary to overcome the social and technical challenges that the specification of a new standard format faces. We hope – and believe – that this should foster a more efficient research in neuroimaging.