# Standardizing neuroimaging atlases formats

## Introduction

Brain atlases are widely used in brain imaging to associate a structural – or functional- label to a position in a coordinate system, often defined with a brain template such as the MNI 305 space. Most atlases are composed of a series of images, or consist in one parcellated image of a typical or averaged brain, associated with 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 format of these atlases varies. 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), the Automatic Anatomical Labelling (AAL), the Freesurfer labels, the JuBrain labels, amongst the most used atlases do not represent the information in a consistent manner. There is also a growing number of functional parcellations and atlases of functional networks.

While atlases are ubiquitous and in growing 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, is error prone, makes the combination of atlases difficult preventing easy experimentation and comparison, and more broadly, the absence of a clear description and format make 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 benefited from the International Neuroinformatics Coordinating Facility neuroimaging data sharing and atlasing programs, and gathered a group of researchers with competences 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 brain Institute 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.

We met in person at the MNI in Montreal to first establish the specifications and use cases of this new format, and second at the MIT to create a few examples of atlases following this specification. We used the collaborative development tools such as Google documents and GitHub to further discuss and improve these specifications and 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 semantic level information (the description of structures, the labels, etc) from the low level information – the image format. 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 very 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. Already some validation tools are emerging for the <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 propose reference implementations in current neuroimaging software (SPM, FSL, Afni, FreeSurfer, MNI Display, MRIcro, Allen Brain tools, and others).

## Conclusion

The International Neuroinformatics Coordinating Facility allows to create and fund working groups and help 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 think – that this should foster a more efficient research in neuroimaging.