

# Waxholm Space atlas of the Sprague Dawley rat brain

## Note on coordinate systems in the WHS rat brain atlas

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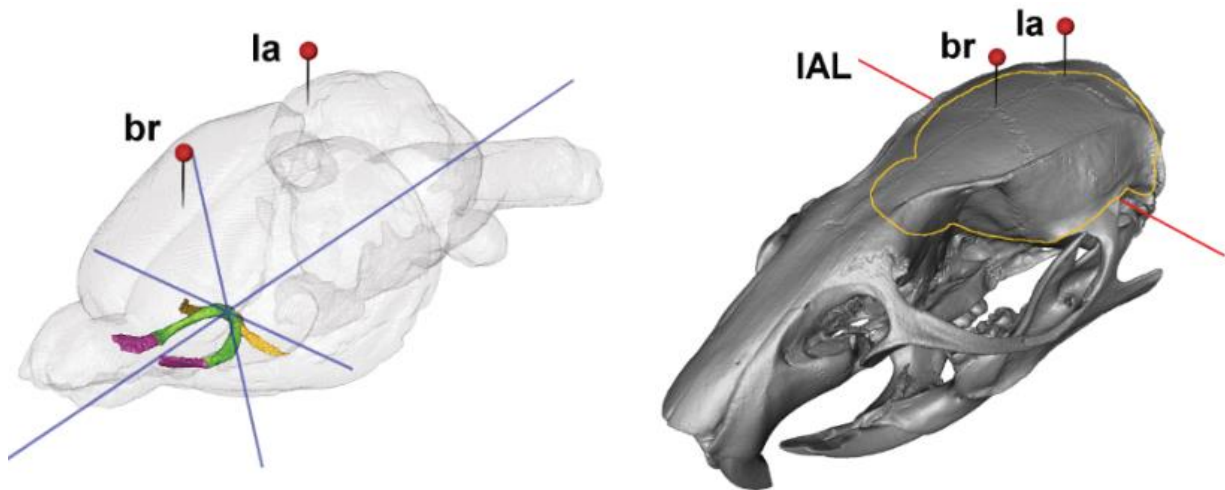
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The Waxholm Space (WHS) rat brain atlas (Papp et al., 2014) is spatially defined by the Waxholm Space coordinate system, applied to a high-resolution magnetic resonance imaging data set. The coordinate system is defined using internal landmarks, following the recommendations of the INCF Working Group on Digital Brain Atlasing (Hawrylycz et al., 2009, 2011; Johnson et al., 2010). In addition, the cranial landmarks *bregma* and *lambda* has been identified, allowing translation of Waxholm Space coordinates to stereotaxic coordinates (Paxinos and Watson, 2013; Swanson, 2018). **In this note, we summarize the technical details needed to understand, navigate and translate across coordinate systems.** We briefly describe the anatomical reference points and orientation of the coordinate system used in the WHS rat brain atlas (v. 1.01), together with a table providing landmark coordinates. We also explain the spatial relationship of the WHS stereotaxic coordinate system relative to the flat skull position used in stereotaxic atlases, which is relevant for using the WHS rat brain atlas for stereotaxic surgery or when comparing location information between rat brain atlases.

### Coordinate systems of the WHS SD rat brain atlas

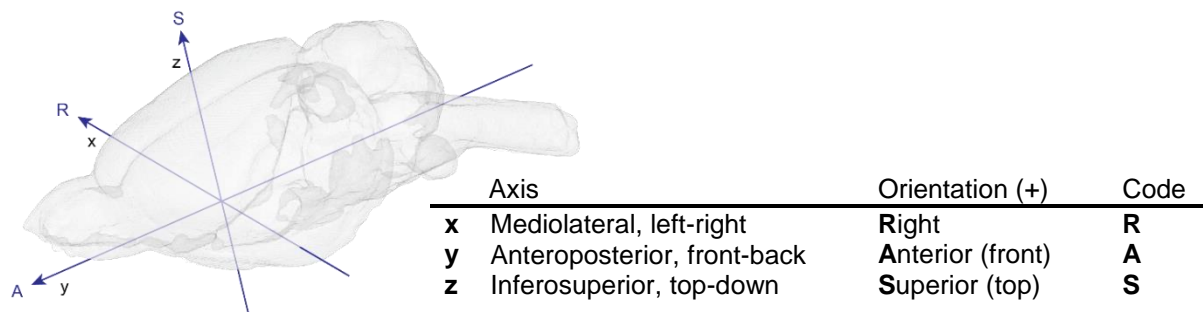
The Waxholm Space is a Cartesian coordinate system with the origin set at the decussation of the anterior commissure, defined by internal brain landmarks. Based on observations of the coronal, sagittal and lambdoid cranial sutures in the MRI template, the position of the *bregma* and *lambda* points were defined at the intersection of the sagittal and coronal or lambdoid sutures, respectively. The Waxholm Space origin and the cranial landmarks are illustrated in Figure 1. For a full description on identification of these landmarks in the WHS SD rat brain atlas, see the original publication (Papp et al., 2014). The landmark coordinates are given in Table 1.



**Figure 1.** Illustration of the internal and external reference points used for defining the Waxholm Space and stereotaxic coordinate systems, respectively. The Waxholm Space is defined with its origin set at the decussation of the anterior commissure (crossing of blue lines in the left panel). Cranial landmarks, here illustrated on an image of a rat skull, were also identified in the MRI dataset. Figure adapted from Papp et al. (2017).

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The WHS SD rat brain atlas uses a RAS (rostral-anterior-superior) orientation. This means that the x axis is oriented towards the right, the y axis towards anterior and the z axis towards superior (Figure 2). Note that the first version (v1.0) of the atlas used a different orientation (anterior-left-superior, ALS), and that this was changed in the new version (v1.01) to standardize the volumes according to the NIfTI-1 standard (for details, see the related [release note](#)).



**Figure 2.** Illustration of the orientation of the WHS rat brain atlas.

## Using stereotaxic coordinates from the WHS SD rat brain atlas

The WHS rat brain reference data were acquired with the rat head approximately in the flat skull position, where the height of the cranial landmarks *bregma* and *lambda* is at the same horizontal level (Paxinos and Watson, 1998). In the WHS rat brain atlas v1.01 (Papp et al., 2015), the dorsoventral position of *bregma* (7.5000000 mm) and *lambda* (8.4375000 mm) are slightly different, with *lambda* located ~0.93 mm superior to *bregma*, meaning there is a 4-degree deviation from the flat-skull position (coordinates are given in Table 1, below). When using the WHS rat brain atlas to in context of stereotaxic surgery, or when comparing coordinates to other stereotaxic rat brain atlases (Paxinos and Watson, 2013; Swanson, 2018), this deviation from the stereotaxic flat-skull position should be taken into consideration.

		High resolution (39µm)			Low resolution (78 µm)		
		Voxels	WHS voxels	WHS mm	Voxels	WHS voxels	WHS mm
<b>WHS origin</b>							
Mediolateral	<b>x</b>	244	0	0.0000000	122	0	0.0000000
Anteroposterior	<b>y</b>	623	0	0.0000000	311.5 <sup>1</sup>	0	0.0000000
Inferosuperior	<b>z</b>	248	0	0.0000000	124	0	0.0000000
<b>Bregma (br)</b>							
Mediolateral	<b>x</b>	246	2	0.0781250	123	1	0.0781250
Anteroposterior	<b>y</b>	653	30	1.1718750	326.5 <sup>1</sup>	15	1.1718750
Inferosuperior	<b>z</b>	440	192	7.5000000	220	96	7.5000000
<b>Lambda (la)</b>							
Mediolateral	<b>x</b>	244	0	0.0000000	122	0	0.0000000
Anteroposterior	<b>y</b>	442	-181	-7.0703125	221	-90.5 <sup>1</sup>	-7.0703125
Inferosuperior	<b>z</b>	434	216	8.4375000	232	108	8.4375000

**Table 1: Coordinates for WHS origin, bregma and lambda.** The coordinates are available in voxels, WHS voxels and WHS mm for both the high (39µm) and low (78 µm) resolution data sets (adapted from Papp, 2017). <sup>1</sup> We use voxel coordinates with a .5 value so that identical metric WHS coordinates are retrieved for identical anatomical points of interest in both the high resolution and the low resolution datasets. This is realized in the NIfTI files by storing the WHS origin in metric coordinates (see the *qoffset* and *srow* fields of the header). Note that voxel coordinates are not identical to slice numbers. For example, in an 512\*512\*1024 volume, slice numbers range between (1..512; 1..512; 1..1024), while voxel coordinates range between (0..511; 0..511; 0..1023).

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