Digital Brain Atlases
Valuable Research Tool or Emperor's New Clothes?

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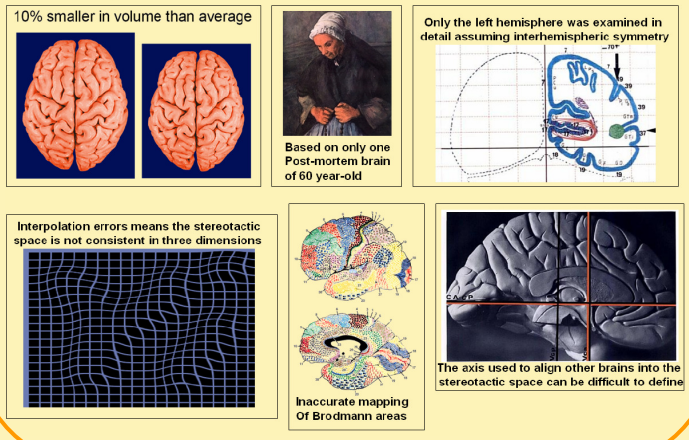
THE DISCONNECTED MIND

Introduction

Digital brain atlases are widely used to register image data into a common space and to automatically segment the whole brain and key subregions. The anatomical accuracy of individual atlases has been queried[1], and discrepancies between atlases highlighted.[2]

The stereotactic atlas of Talairach&Tournoux (1988),[3] had a major impact in combination with CT & MRI, initially among neurosurgeons, then increasingly in research, despite significant limitations (as below).

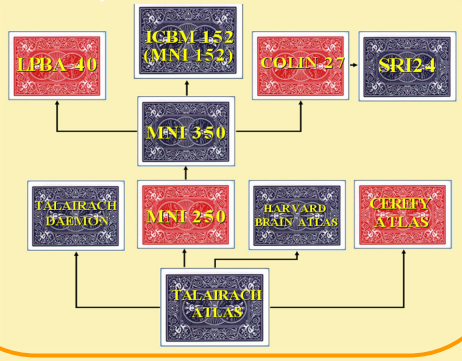
Summary of flaws in the original Talairach Atlas



The House of Cards

A succession of brain atlases have employed increasingly sophisticated imaging and registration methods to improve accuracy.

However, the most widely used current atlases, including the "gold standard" MNI 152, endorsed by the International Consortium for Brain Mapping, used Talairach as the original reference frame. We contend such atlases are built on questionable foundations.

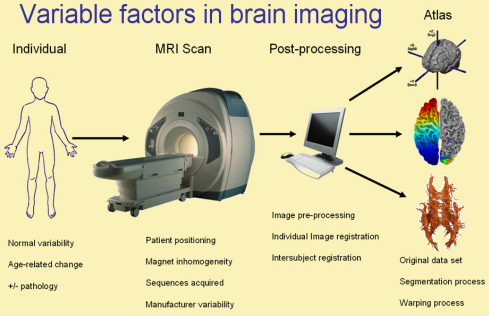


Square pegs into round holes?

Brain architecture varies from person to person (including identical twins), with age and in different diseases.
Atlases based on few brains are unrepresentative. Those which fuse numerous brains lose anatomical detail, particularly in the cortical gyri. Producing an approximation of the anatomical reality, they are termed "probablistic".

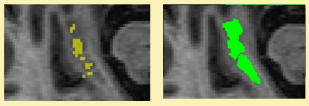
Specialised brain atlases to examine specific brain regions and particular diseases have been created, but at the loss of ready comparison with data from other studies.

Variable factors in brain imaging



Our own experience

In the LBC study, hippocampal volumes are being assessed. Utilising FSL_FIRST software and the MNI 152 brain atlas, 32 brains were automatically segmented, delineating each hippocampus.
The accuracy was checked independently by two radiologists.
14 of 64 hippocampi were delineated with a high degree of accuracy (only 22%), with significant errors found in 12 (19%).



Left-hand image shows automated segmentation of the right hippocampus, which has underestimated the volume (yellow pixels).

The right-hand image demonstrates manual segmentation performed by a radiologist (green pixels).

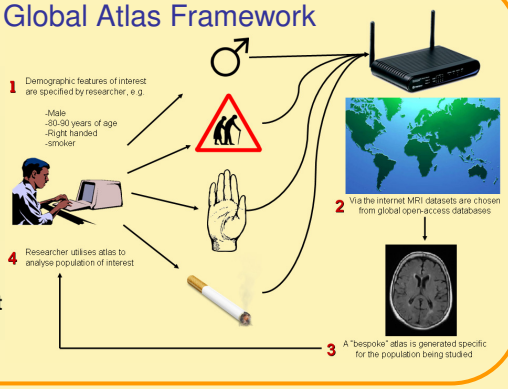
Room for improvement? A suggested Global Atlas Framework

Production of atlases which are both representative and yet allow comparison of data is a major challenge.

The scheme illustrated to the right would allow atlases tailored to the needs of the researcher or clinical radiologist to be created.

International agreement of technical protocols would be required to reduce variability between datasets.

Global collaborations such as the Human Genome project suggest such a scheme could be feasible.



Summary

Digital brain atlases offer exciting research opportunities and could help clinical radiology. However, anyone who has ever used a satnav will know to treat electronic navigation with a pinch of salt from time to time.

Our work suggests this is equally true of such brain atlases, which require refinement to become accurate and reliable research tools.

References

(1)Devlin JT, Poldrack RA. In praise of tedious anatomy. NeuroImage 2007 Oct 1;37(4):1033-41.
(2)Bohland JW, Bokil H, Allen CB, Mitra PP. The Brain Atlas Concordance Problem: Quantitative Comparison of Anatomical Parcellations. PLoS ONE 2009 Sep 29;4(9):e7200.
(3) Talairach, JPT. Co-Planar Stereotaxic Atlas of the Human Brain. Thieme, 1988.

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