Mapping the lesioned brain

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Introduction

Science has developed powerful ways to visualize the structure of the brain, but correlating physical and emotional manifestations of the brain to specific locations in the brain has been more difficult. Individuals who have suffered brain damage (referred to as a lesion) and who show behavioral abnormalities as a result are helping medical researchers to develop an understanding of how brain structure correlates with behavior.

Just as people come in different sizes and shapes, so do their brains. This prevents researchers from being able to directly compare brain lesions, but these differences can be reconciled by replicating the anatomy of the lesion onto a template brain. The MAP3 method provides the tools necessary to create these maps.

Meet PC

PC is our template brain. We use PC’s magnetic resonance images (MRI) as a template on which to replicate lesions that have been identified in the MRIs of patients.

The image below includes labels of the four cortices of the brain (red, blue, green, and yellow) and the cerebellum.

Meet FE

Patient FE suffered from HSE (Herpes Simplex Encephalitis) at the age of 19. Despite the degree of damage incurred as a result of HSE, FE is a very successful businessperson. The symptoms that FE exhibits include partial retrograde amnesia (an inability to recall memories) and visuospatial and visuoperceptual deficits.

The image to the left shows the orientation of FE’s MRI in “native space”. Native space is the set of coordinates that represents the orientation of FE’s brain at the time the MRI was taken. In order to represent FE’s lesion accurately, we consider FE’s coordinates in space to be 0, 0, 0 and rotate PC to match FE.

The images above show the lesion volume in FE (left), and the corresponding region in PC (right). The alignment process includes re-engineering the interslice distance of PC to that of FE. This ensures that there will be a one-to-one relationship between the images in the lesion volume.

In this case, PC was warped from 0.9375 mm per image slice to 1.059 mm per image slice, allowing the number of images within PC’s lesion volume to match the 50 images in FE’s lesion volume.

Multiple lesion analysis

Now we have a 3D representation of FE’s lesion that is in a spatial representation that allows us to compare the lesion to other lesions that are in the same spatial representation.

When a common behavioral manifestation among a group of patients is identified, we can use the maps of their lesions to determine “hot spots”; damaged regions that the patients have in common. By identifying the structure(s) that seem to be most frequently damaged given one behavioral trait, we can begin to determine the anatomical substrate of that behavior.

The above images show the map of FE’s lesion on PC’s brain. The damaged areas are assigned a value of 1, and the rest of the brain has a value of 0. When we overlay the maps of multiple individuals, the summation of the regions of damage results in a heat map, as shown below. This map compares FE with nine other patients.

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For further information

https://bicn.neurology.uiowa.edu/wiki/doku.php

The scale bar indicates the number of patients who show damage within each 3D pixel (“voxel”), thereby quantifying the amount of damage per voxel.