Interaction and collaboration in Neuroinformatics — possibly in VRML

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OVERVIEW

Title of PhD:
Analysis, Visualization and Meta-analysis of neuroimages

Task (one of them):
To make an environment — a program! — that makes collaboration and interaction easier between brain researcher.

- What is neuroinformatics
- "Manual" neuroinformatics
- BrainMap
- Environment
- VRML
- Immersive display
- Conclusion

Application-oriented!

NEUROINFORMATICS

Neuroinformatics

Organization of knowledge about the brain.
[Koslow and Huerta, 1997, Hirsch and Koslow, 1999]

Brain mapping neuroinformatics

Organization of knowledge about cognitive processes and brain anatomy: functional anatomy.

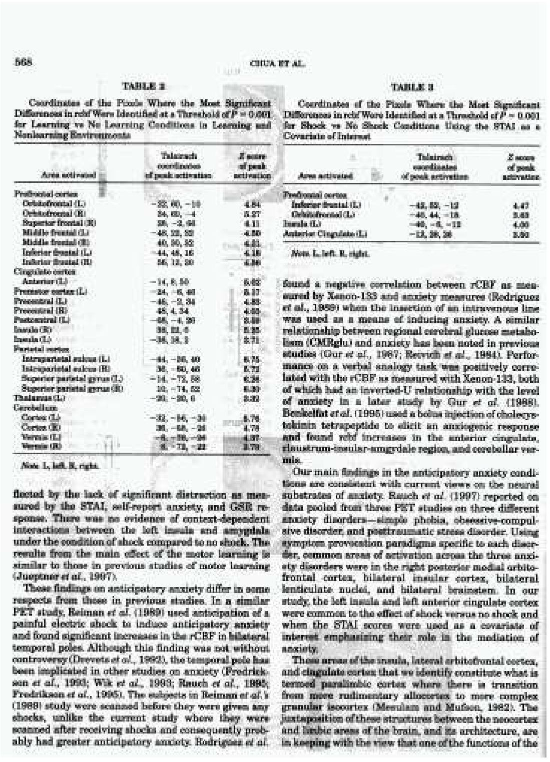

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TABLE 2

Coordinates of the Pixels Where the Most Significant Differences in rcbf Were Identified at a Threshold of P = 0.001 for Learning vs No Learning Conditions in Learning and Nonlearning Environments

Area activated	Talairach coordinates of peak activation	Z score of peak activation
Prefrontal cortex		
Orbitofrontal (L)	−22, 60, −10	4.84
Orbitofrontal (R)	34, 60, −4	5.27
Superior frontal (R)	38, −2, 64	4.11
Middle frontal (L)	−48, 22, 32	4.80
Middle frontal (R)	40, 50, 32	4.81
Inferior frontal (L)	−44, 48, 16	4.18
Inferior frontal (R)	56, 12, 20	4.86
Cingulate cortex		
Anterior (L)	−14, 8, 50	5.62
Premotor cortex (L)	−24, −6, 60	5.17
Precentral (L)	−46, −2, 34	4.83
Precentral (R)	48, 4, 34	4.03
Postcentral (L)	−66, −4, 20	5.69
Insula (R)	38, 22, 6	5.25
Insula (L)	−38, 18, 2	5.71
Parietal cortex		
Intraparietal sulcus (L)	−44, −36, 40	6.75
Intraparietal sulcus (R)	36, −60, 46	5.72
Superior parietal gyrus (L)	−14, −72, 58	6.26
Superior parietal gyrus (R)	10, −74, 52	6.30
Thalamus (L)	−20, −20, 6	3.22
Cerebellum		
Cortex (L)	−32, −56, −30	5.76
Cortex (R)	36, −68, −26	4.78
Vermis (L)	−6, −56, −26	4.97
Vermis (R)	8, −72, −22	3.79

Note. L, left; R, right.

TABLE 3

Coordinates of the Pixels Where the Most Significant Differences in rcbf Were Identified at a Threshold of P = 0.001 for Shock vs No Shock Conditions Using the STAI as a Covariate of Interest

Area activated	Talairach coordinates of peak activation	Z score of peak activation
Prefrontal cortex		
Inferior frontal (L)	−42, 52, −12	4.47
Orbitofrontal (L)	−46, 44, −18	3.63
Insula (L)	−40, −6, −12	4.00
Anterior Cingulate (L)	−12, 28, 20	3.50

Note. L, left; R, right.

flected by the lack of significant distraction as measured by the STAI, self-report anxiety, and GSR response. There was no evidence of context-dependent interactions between the left insula and amygdala under the condition of shock compared to no shock. The results from the main effect of the motor learning is similar to those in previous studies of motor learning (Jueptner *et al.*, 1997).

These findings on anticipatory anxiety differ in some respects from those in previous studies. In a similar PET study, Reiman *et al.* (1989) used anticipation of a painful electric shock to induce anticipatory anxiety and found significant increases in the rCBF in bilateral temporal poles. Although this finding was not without controversy (Drevets *et al.*, 1992), the temporal pole has been implicated in other studies on anxiety (Fredrikson *et al.*, 1993; Wik *et al.*, 1993; Rauch *et al.*, 1995; Fredrikson *et al.*, 1995). The subjects in Reiman *et al.*'s (1989) study were scanned before they were given any shocks, unlike the current study where they were scanned after receiving shocks and consequently probably had greater anticipatory anxiety. Rodriguez *et al.* found a negative correlation between rCBF as measured by Xenon-133 and anxiety measures (Rodriguez *et al.*, 1989) when the insertion of an intravenous line was used as a means of inducing anxiety. A similar relationship between regional cerebral glucose metabolism (CMRglu) and anxiety has been noted in previous studies (Gur *et al.*, 1987; Reivich *et al.*, 1984). Performance on a verbal analogy task was positively correlated with the rCBF as measured with Xenon-133, both of which had an inverted-U relationship with the level of anxiety in a later study by Gur *et al.* (1988). Benkelfat *et al.* (1995) used a bolus injection of cholecystokinin tetrapeptide to elicit an anxiogenic response and found rcbf increases in the anterior cingulate, claustrum-insular-amygdala region, and cerebellar vermis.

Our main findings in the anticipatory anxiety conditions are consistent with current views on the neural substrates of anxiety. Rauch *et al.* (1997) reported on data pooled from three PET studies on three different anxiety disorders—simple phobia, obsessive-compulsive disorder, and posttraumatic stress disorder. Using symptom provocation paradigms specific to each disorder, common areas of activation across the three anxiety disorders were in the right posterior medial orbitofrontal cortex, bilateral insular cortex, bilateral lenticulate nuclei, and bilateral brainstem. In our study, the left insula and left anterior cingulate cortex were common to the effect of shock versus no shock and when the STAI scores were used as a covariate of interest emphasizing their role in the mediation of anxiety.

These areas of the insula, lateral orbitofrontal cortex, and cingulate cortex that we identify constitute what is termed paralimbic cortex where there is transition from more rudimentary allocortex to more complex granular isocortex (Mesulam and Mufson, 1982). The juxtaposition of these structures between the neocortex and limbic areas of the brain, and its architecture, are in keeping with the view that one of the functions of the

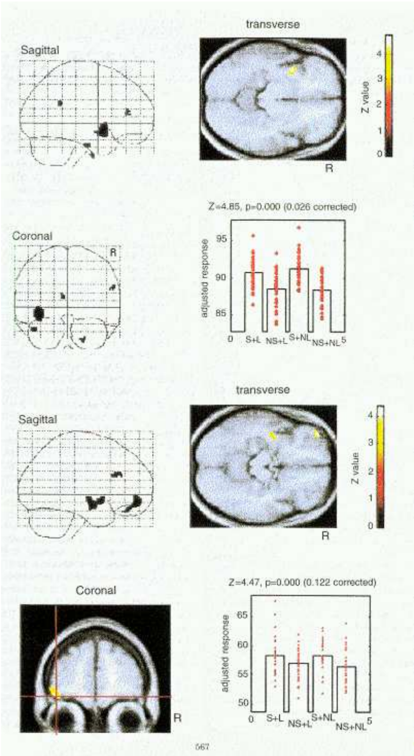
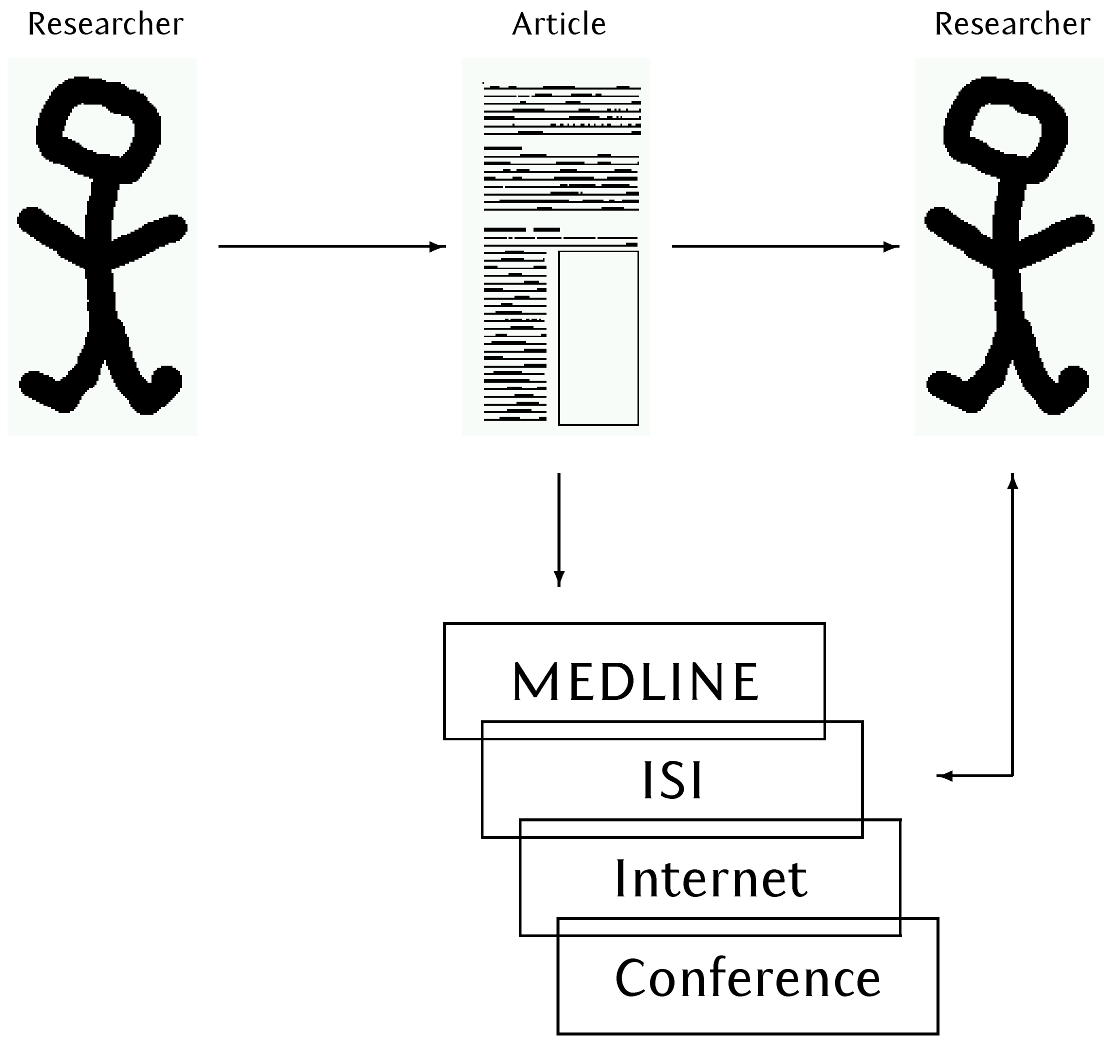


Figure 1: From the article [Chua et al., 1999] about anticipatory anxiety. Activation hot spots in so-called Talairach coordinates [Talairach and Tournoux, 1988].

"MANUAL" NEUROINFORMATICS



The researcher asks two questions:

- How is the study relating to other similar studies? Function → anatomy.
- Which other studies finds activations a similar sites? Anatomy → function. Difficult!

BRAINMAP

- BrainMap [Fox and Lancaster, 1994]:
  - BrainMap Database (SQL RDBM)
  - BrainMap Entry
  - BrainMap Search & View (GUI)
- Database contains data from functional neuroimaging studies with "Talairach coordinates".
  - Original peer-reviewed papers
  - Meta-analyses
- Paper (title, author, abstract), structured description of the study (behavioral domain, modality, tracer) and Talairach coordinates

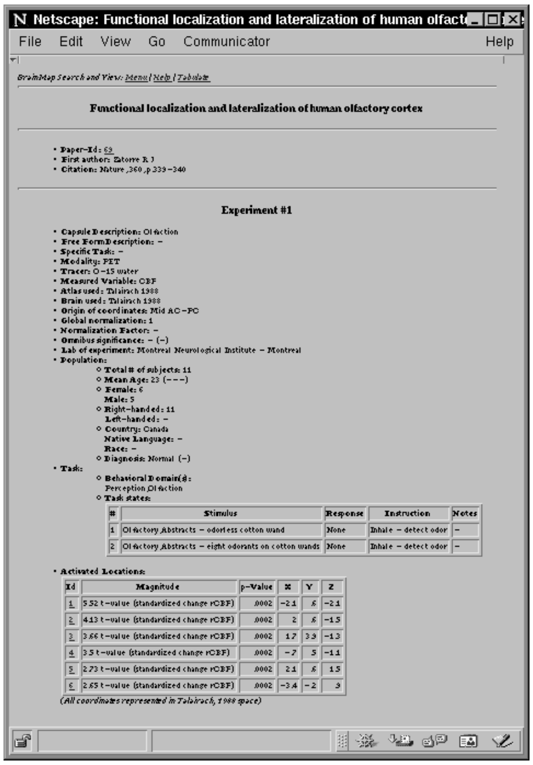


Figure 2: From the BrainMap homepage `http://ric.uthscsa.edu`.

BRAINMAP

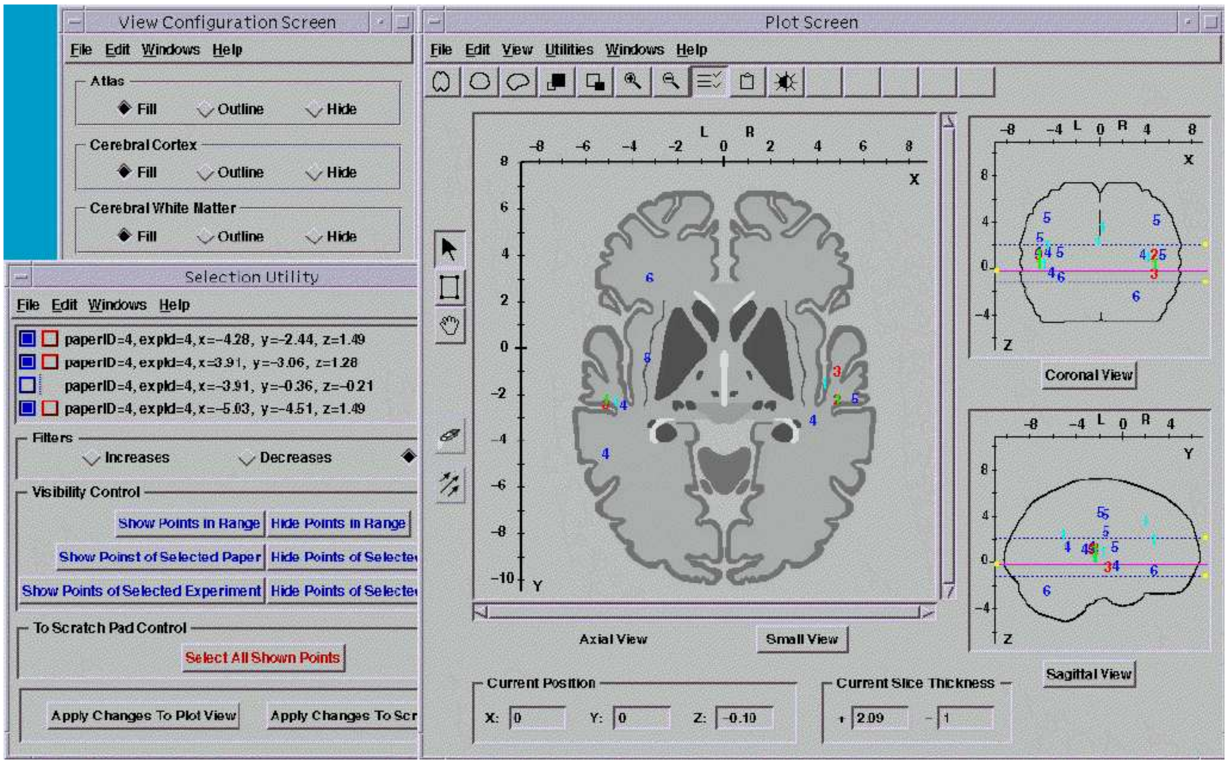


Figure 3: Figure from the BrainMap homepage. The Search & View program [Lancaster et al., 1997].

Disadvantage with BrainMap

- Not easy to move the database, e.g., put it on a CD-ROM or mirror it.
- Does not take full advantage of the collaborative effort for the entry of the data, although the BrainMap Entry program was distributed to some laboratories.
- Not platform-independent graphical visualization.

MY APPROACH

- Simple database. Text easy to enter, e.g., a modified BibTeX format.
- Matlab program: highly used in the neuroimaging community. Provides interactive command-line computations and plotting.
- Output to VRML:

  A 3D symbol environment — the CornerCube environment — have shown an advantage over typical 2D displays [Rehm et al., 1998].

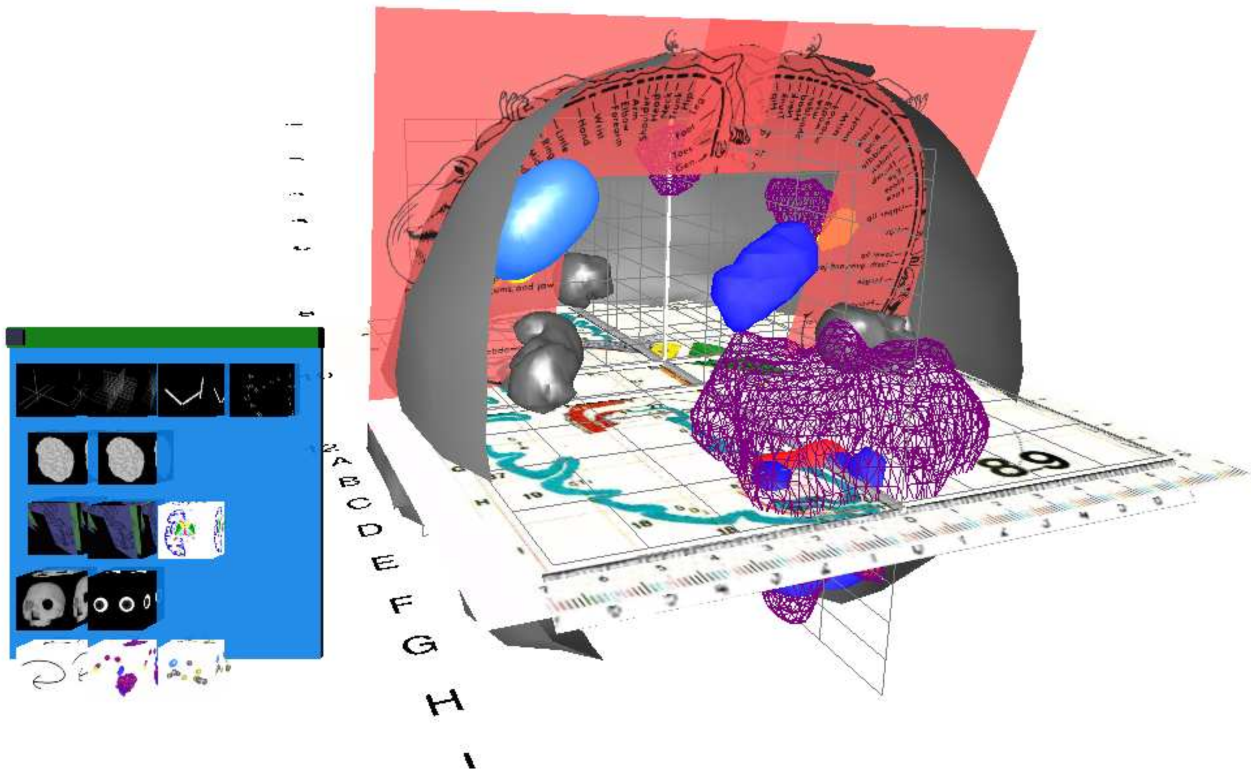


Figure 4: VRML display of activations

EXAMPLE

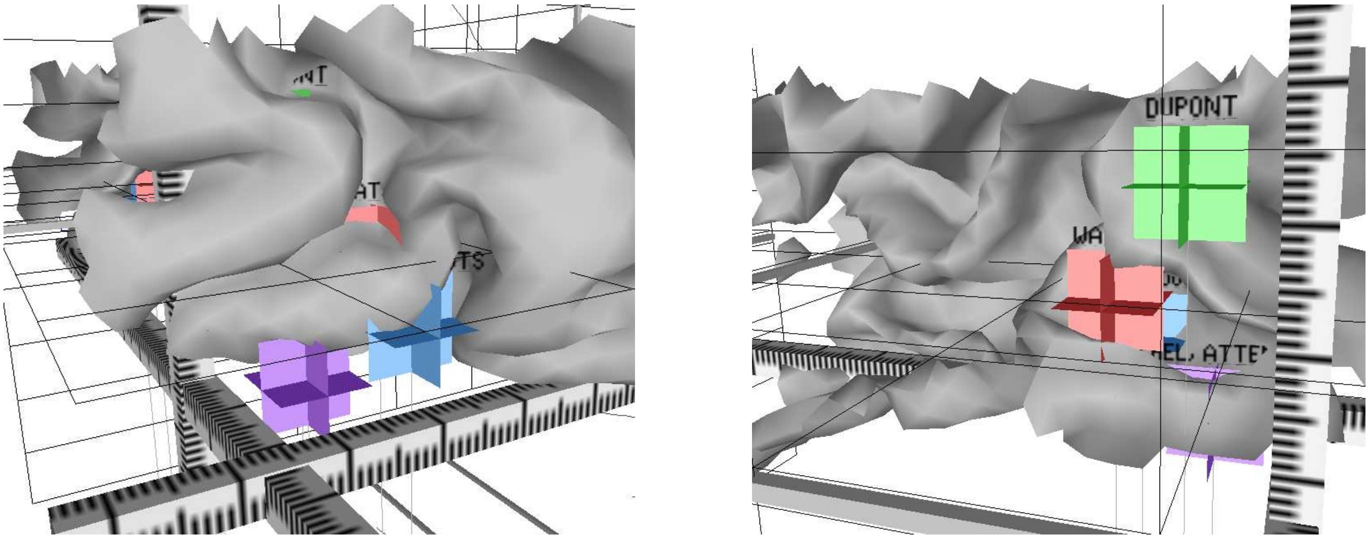


Figure 5: Visual motion studies VRML-world generated with Matlab programs.

- The data is static, but you might want to hide information to avoid overloading and you might want to query for new data.
- Limited amount of interaction in present version of VRML-world: Movement of the axis, click activations on and off.
- The glyphs are hyperlinked.
- Further imaginable interactions: Glyphs that expand and reveal new information.
- Difficult to make complex interaction in VRML!

EXAMPLE: NOVELTY DETECTION

- Novelty detection: Take a new study and what the probability for obtaining such a study.
- Use of statistics to model the probability.

Automatic labeling

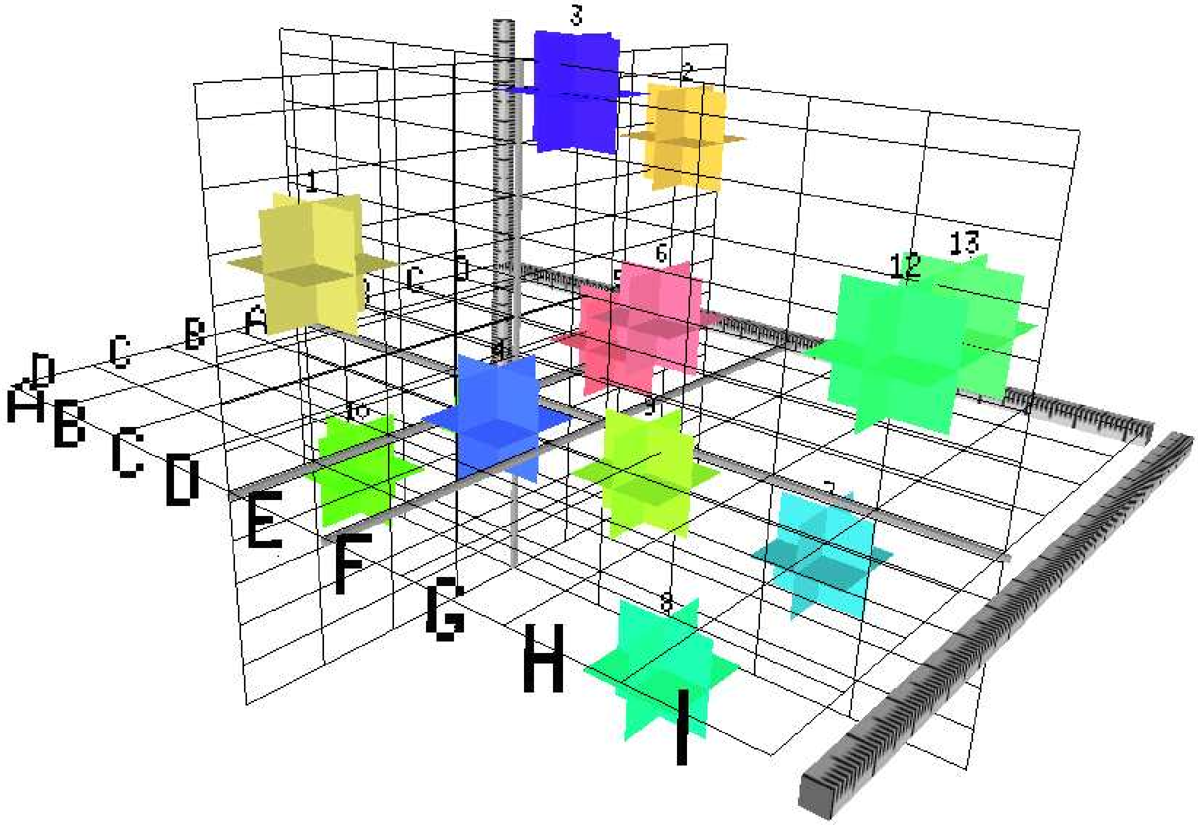


Figure 6: Automatic labeling detection on each individual Talairach coordinate from a paper: [Law et al., 1998].

EXAMPLE: INFORMATION VISUALIZATION

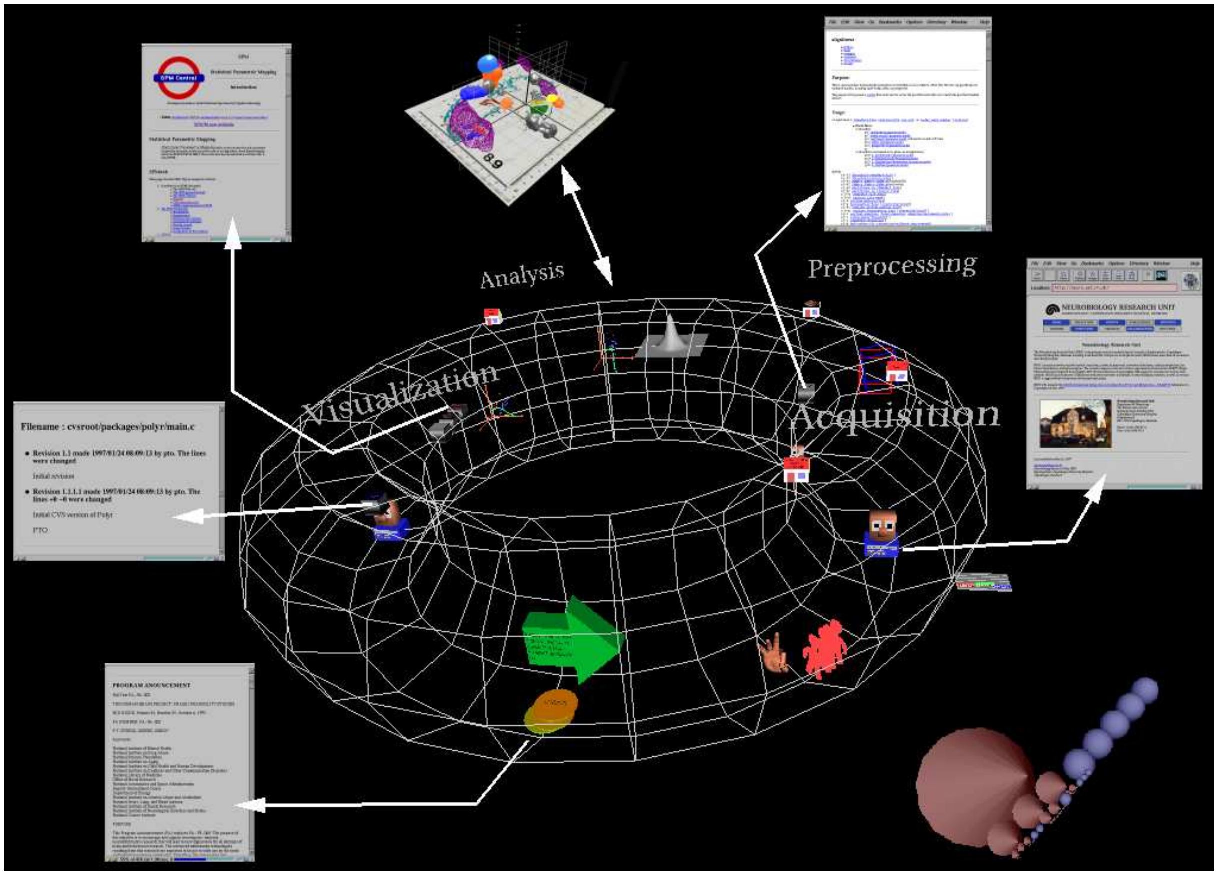


Figure 7: Information visualiztion. A process: Initial hypothesis, scanning, analysis and lastly interpretation, which links to the initial hypothesis.

- Visualize every kind of data that is generated in a neuroimaging study.
- Supplement to textual information.

IMMERSIVE DISPLAYS

Figure 8: Head-mounted display with VRML

- Virtual environment systems are yet too complex and expensive for every day use by the researcher. It should be a desktop system.
- The brain is an object, — not an environment. Better to look at than be in.

CONCLUSION & EXPERIENCES

- VRML can produce useful static visualizations.
- Separate the data and the visualization. Do not hide the data and make the data representation as simple as possible.
- Collaboration not directly in the virtual environments, — but rather by sharing data.
- VRML (probably) not well to do complex queries in. Better for simple tasks: Judgement of the size of activations, connections, overlap, ...
- A prototype head-mounted display environment was not comfortable to work with.
- VRML is not as standard language: Browsers does not behave the same and renderings are different.
- Do not work in 3D unless you have to.

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