# Experiences with Matlab and VRML in Functional Neuroimaging Visualizations

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# OVERVIEW

- Functional Neuroimaging and Neuroinformatics
- "Lyngby"
- VRML
- "Brede"
- Matlab and VRML comparison
- Information visualization
- Immersive Displays
- User experience

International Neuroimaging Consortium

- Poster: Kelly Rehm and others. "Symbolic Representation of Neuroimaging Data: the Corner Cube Environment". Implemented in IDL.
- idl2mat. Very simple tool to call Matlab from IDL.

# FUNCTIONAL NEUROIMAGING

## Functional neuroimaging scanning and data

Figure 1: VRML

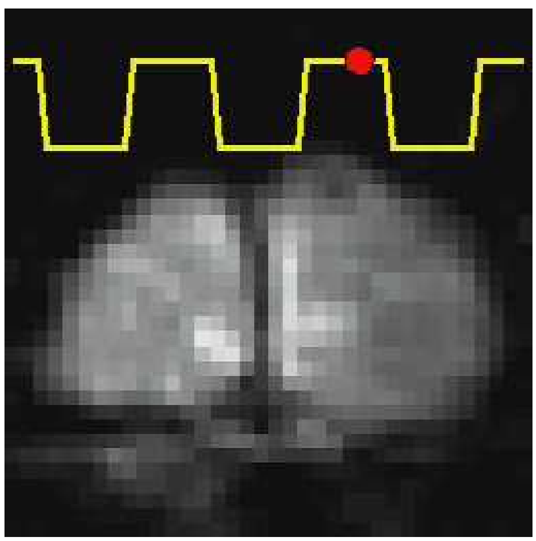

Figure 2: VRML

- 3+1 dimensional datasets

# 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.

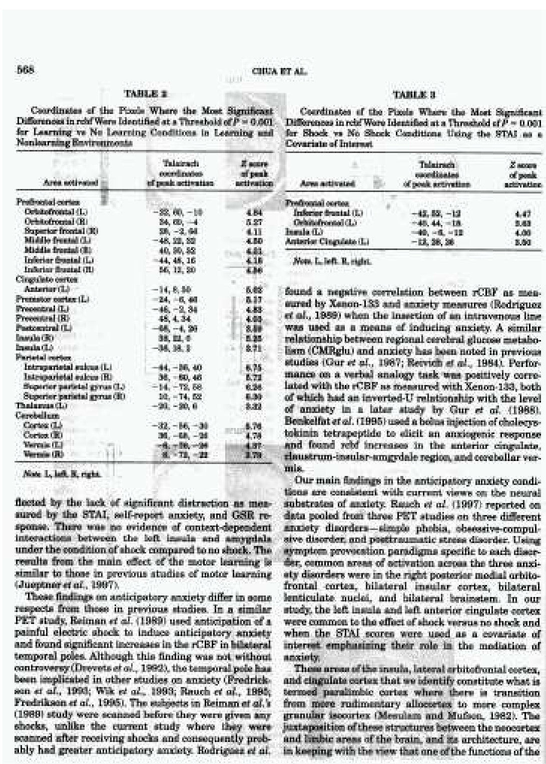

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TABLE 2

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) | −32, 60, −10 | 4.84 |
| Orbitofrontal (R) | 34, 60, −4 | 5.27 |
| Superior frontal (R) | 28, −2, 66 | 4.11 |
| Middle frontal (L) | −48, 22, 32 | 4.80 |
| Middle frontal (R) | 40, 30, 32 | 4.61 |
| Inferior frontal (L) | −44, 48, 16 | 4.18 |
| Inferior frontal (R) | 56, 12, 20 | 4.84 |
| 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) | −58, −4, 20 | 3.89 |
| Insula (R) | 38, 22, 0 | 5.25 |
| Insula (L) | −38, 18, 2 | 3.71 |
| 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 | 3.32 |
| Cerebellum | | |
| Cortex (L) | −32, −56, −30 | 5.76 |
| Cortex (R) | 36, −58, −26 | 4.78 |
| Vermis (L) | −6, −78, −26 | 4.37 |
| Vermis (R) | 8, −72, −22 | 3.78 |

*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.*

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, 26, 26 | 3.50 |

*Note.* L, left, R, right.

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

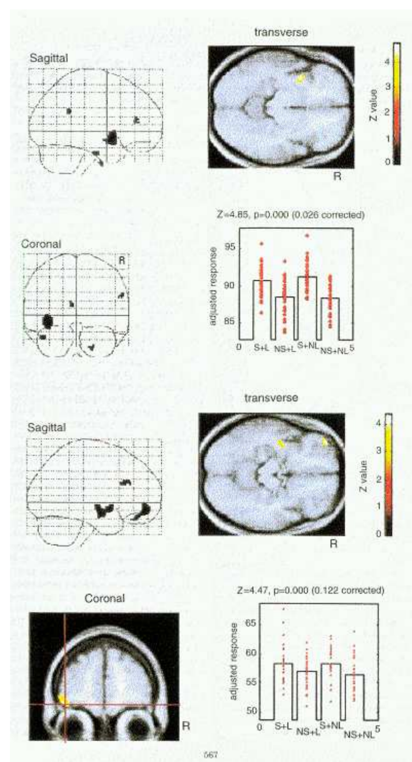


Figure 3: From the article [Chua et al., 1999] about anticipatory anxiety. Activation hot spots in so-called Talairach coordinates [Talairach and Tournoux, 1988].

# "LYNGBY"

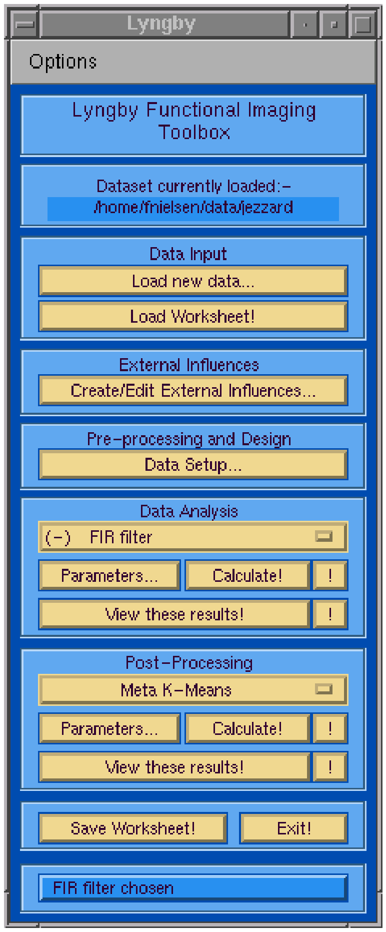


Figure 4: Lyngby

- Functional neuroimaging analysis Matlab toolbox
- Approximately 50,000 lines of pure Matlab code
- GUI + command-line/batch + plot/visualization
- Memory-based. Memory issues put a constraint on the design.
- Analysis + visualization

# "LYNGBY" PLOTS

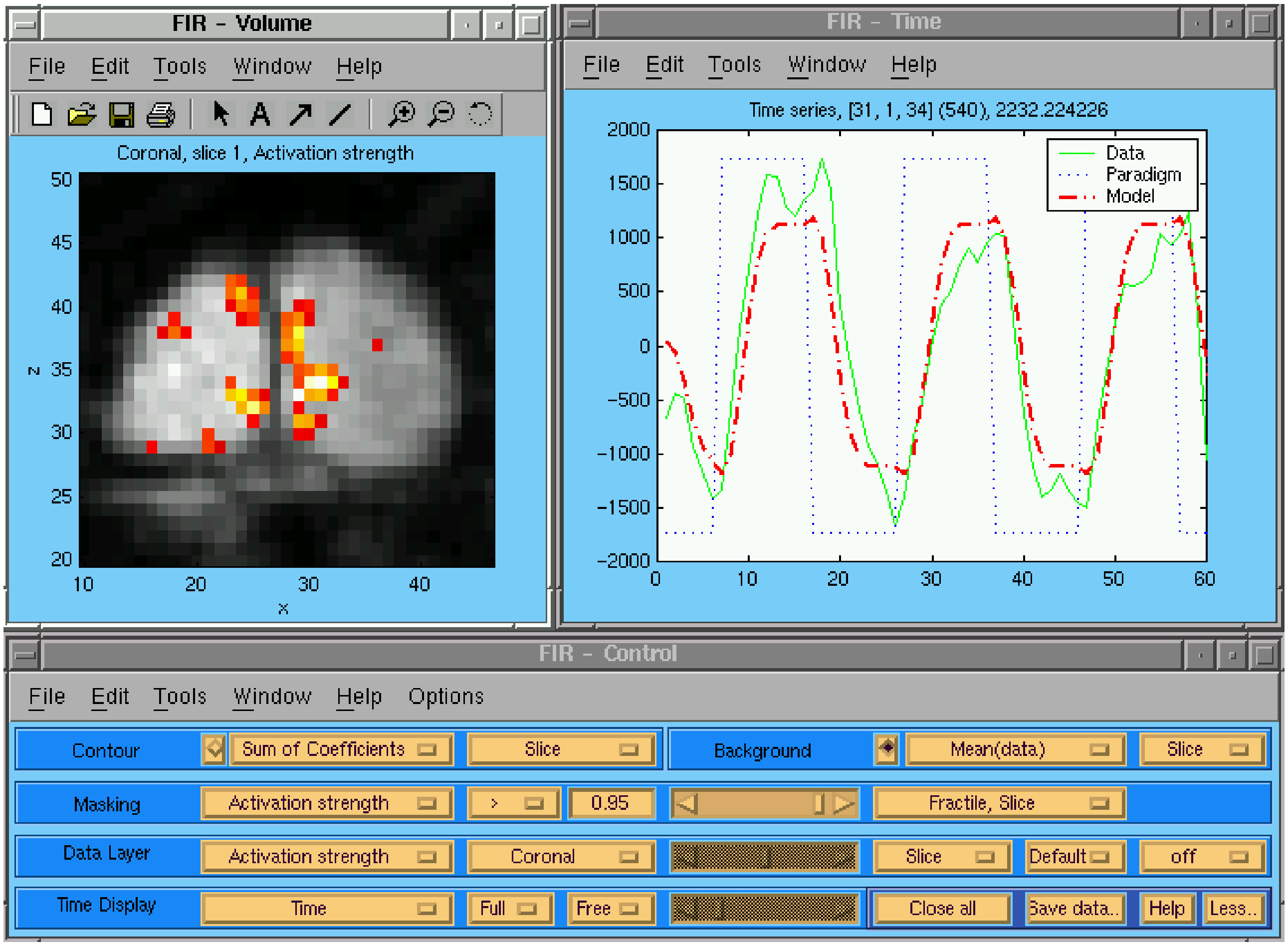


Figure 5: Lyngby

- A click in the left window will update the right
- Left window common for all analyses while right window is draw in a call back function dependent on the analysis

# VRML

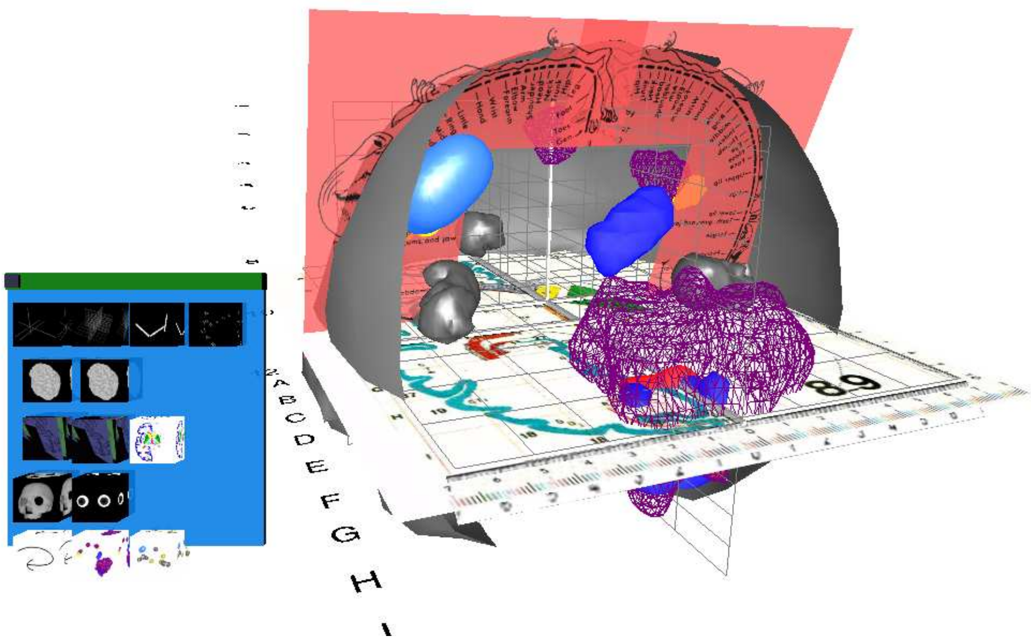

Figure 6: VRML

- Generation of isosurfaces from "polyr" program
- Library of VRML-files
- Simple control devices
- CGI-scripts (Perl)
- Hyperlinks
- Problems with VRML: standardization of script-language, lack of browsers for certain platforms.
- More an output format than a manipulation format
- Distributable on, e.g., CDROM or the Internet

# "BREDE"

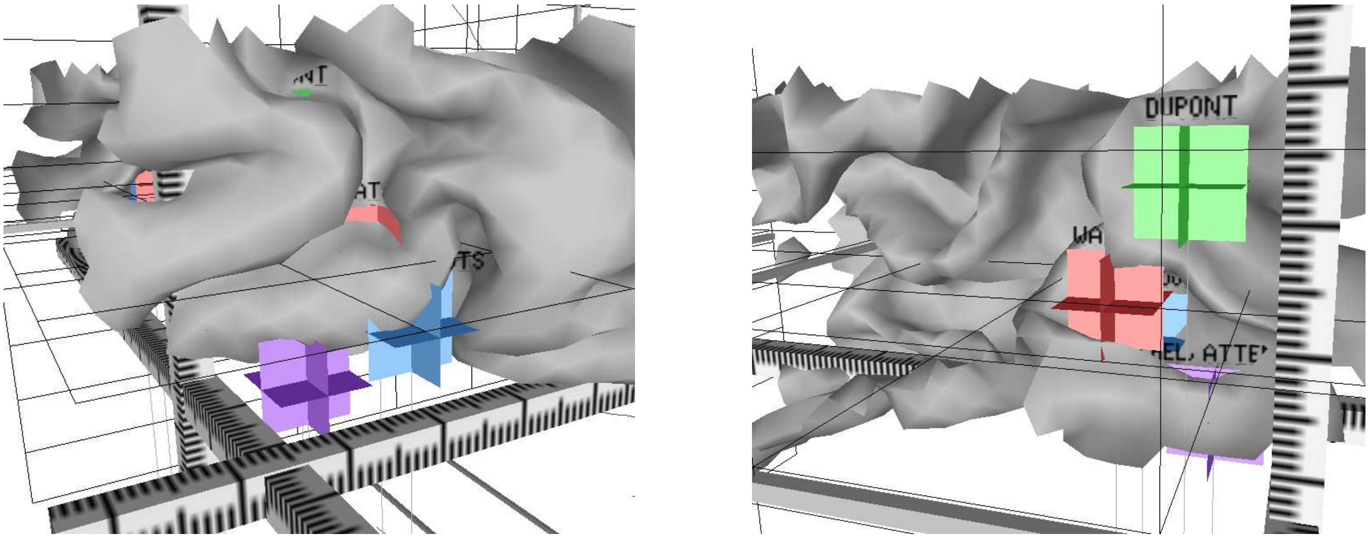


Figure 7: Visual motion studies VRML-world generated with "brede" Matlab toolbox.

- Neuroinformatics Matlab toolbox
- Under development
- Approximately 15,000 lines of code
- Command-line/batch + plot/visualization, no GUI
- Analysis in Talairach space, text analysis, web analysis

# "BREDE"

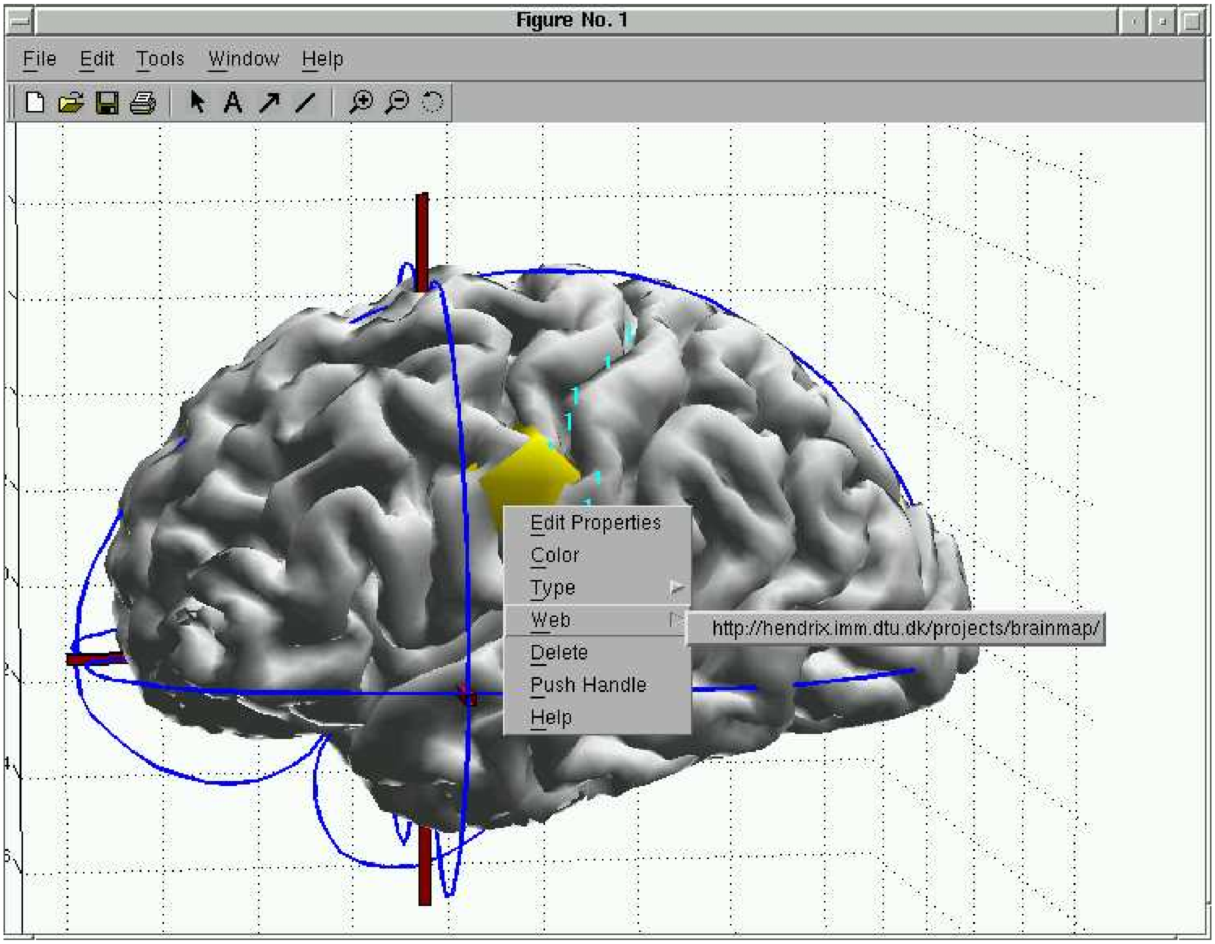


Figure 8: Matlab screenshot

- Reading of distributable database files
- Text analysis: Need of hash and regular expressions matching Difficult with Matlab, as compared with, e.g., Perl
- Web-functions: system calls to Perl, wget or telnet
- Generate VRML and HTML files

# MATLAB AND VRML

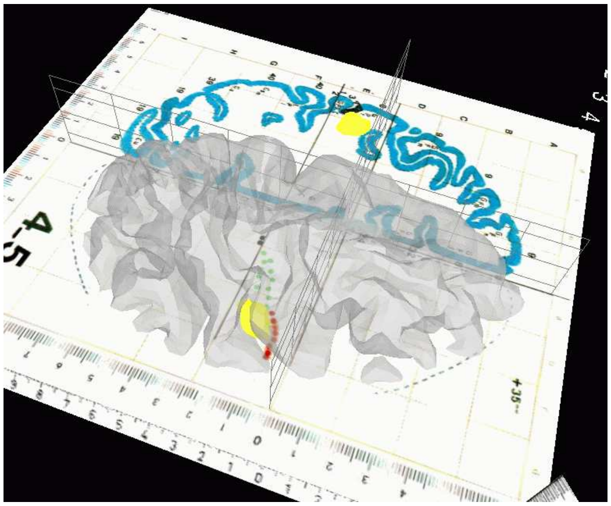

Figure 9: VRML

| | Matlab | VRML |
|---|---|---|
| Color | Indexed/RGB | RGB |
| Scene Graph | "flat" | hierarchical |
| Transparency | no | yes |
| 0 and 1-dim. graphics | yes | (yes) |
| Volume | yes | (no) |
| Interactive | yes | partially |
| Distributable | (yes) | yes |
| Web-integration | (yes) | yes |

Table 1: Matlab and VRML

# INFORMATION VISUALIZATION

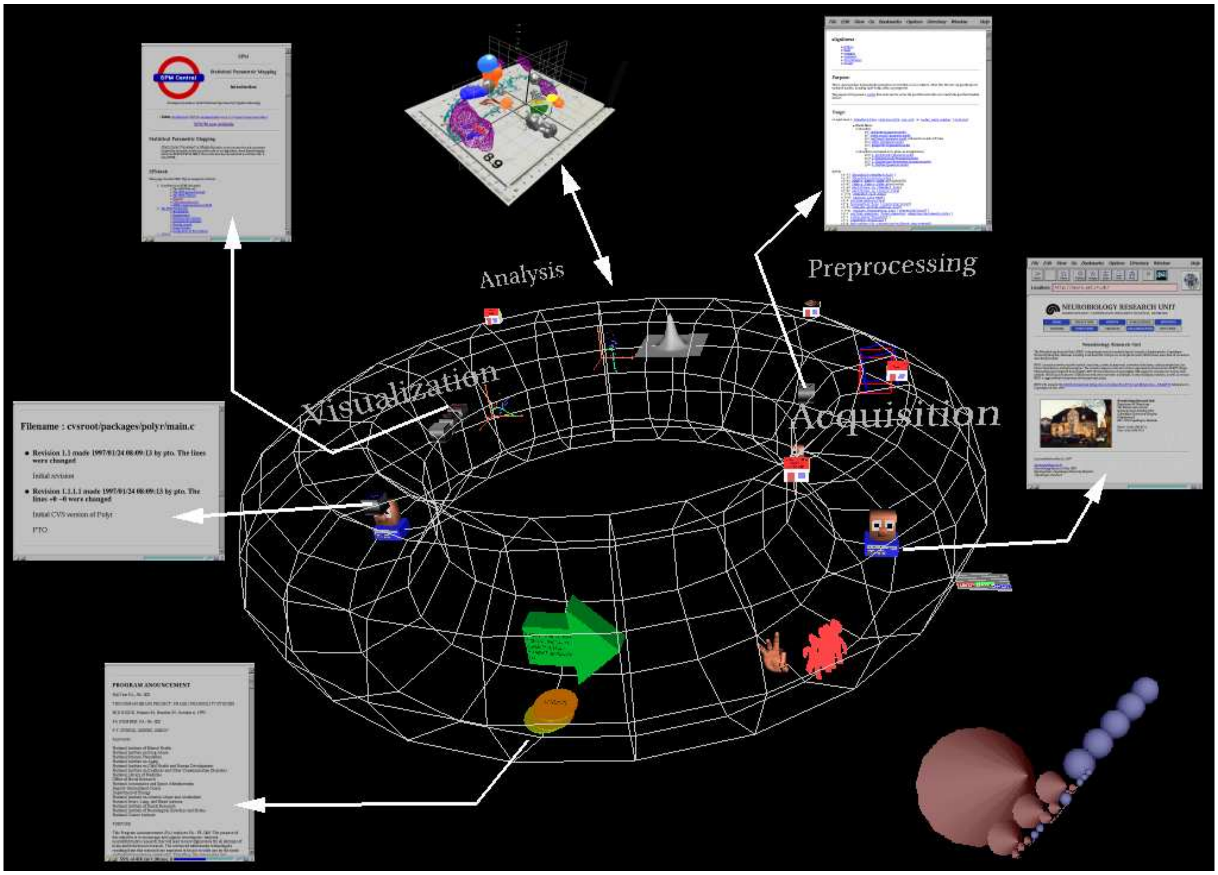


Figure 10: Information visualiztion. A process: Initial hypothesis, scanning, analysis and lastly interpretation, which links to the initial hypothesis.

- Visualize every kind of data that is generated in a neuroimaging study.
- Supplement to textual information.
- Second item in Jakob Nielsen's "Top Ten Mistakes in Web Design".

# IMMERSIVE DISPLAYS

Figure 11: Head-mounted display with VRML

- With headset the enhancement is limited
- Problems with seeing the keyboard and the mouse
- The control interface has to be in the visualization
- Implemented in VRML, — relative simple setup.
- Matlab? Is that possible?

# USERS, EXPERIENCES AND PROBLEMS

- Mailing-list
- Web-based version-history (with cvs2html)
- Web-based calling tree (with mat2html)
- Documentation (latex + help in Matlab)
- Login accounts: Approx. 150, Users: ?

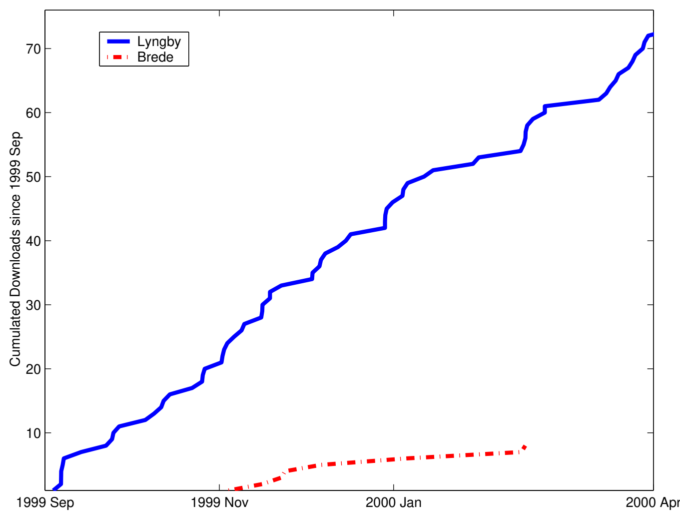


Figure 12: Cumulated downloads since 1999 September

- Mathematical/statistical
- File input/output
- Flexibility (Analysis, Visualization)
- Memory
- Version-problems (5.3, 5.1, Windows/Unix)
- GUI + wants to know whats behind

# CONCLUSION AND WISH-LIST

- In our case analysis and visualization are coupled: The visualization development environment should be supported with mathematical functions
- Users would like to understand the mathematical models and it effect their analysis: Short distance between documentation, code and GUI
- Internet distributable files for the visualizations or database

## Matlab

- Better volume handling
- Transparency
- Text functions: hash, regular expression, parsing

# REFERENCES

## References

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[Talairach and Tournoux, 1988] Talairach, J. and Tournoux, P. (1988). *Co-planar Stereotaxic Atlas of the Human Brain*. Thieme Medical Publisher Inc, New York.