

Integrative properties of the pontine nuclei: exploring the architecture of pathways from somatosensory cortex to the cerebellum with use of a database application

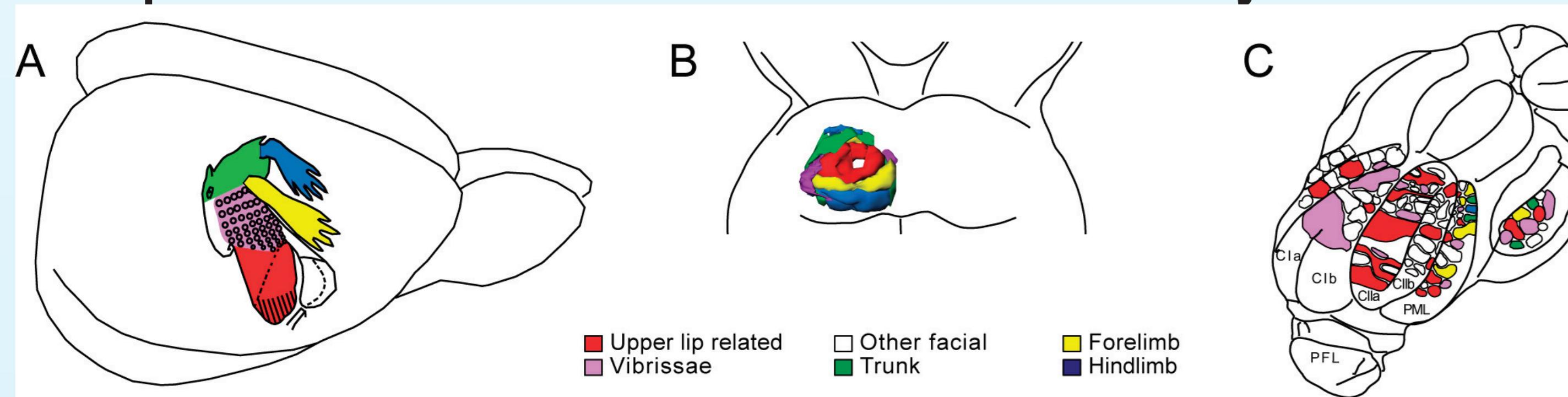
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1. BACKGROUND

The recently published database 'Functional Anatomy of the Cerebro-Cerebellar system' (FACCS) holds previously published data from 78 axonal tracer injections in the cerebral cortex and cerebellar cortex. 3-D computer-reconstructed data representing labeled corticopontine terminal fields and pontocerebellar cell bodies have been mapped into a common spatial framework based on a local coordinate system for the pontine nuclei.

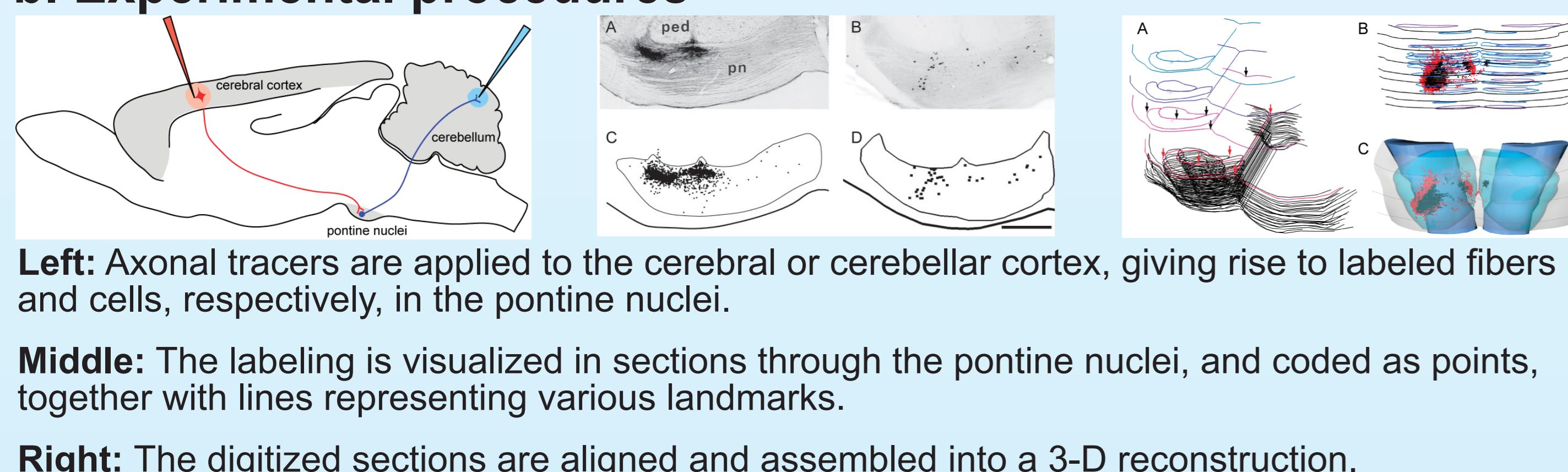
We have combined data from three previous investigations to 1) provide further methodological validation, 2) re-investigate aspects of brain map transformations from the 2-D somatotopic map in SI cerebral cortex to the more complex 3-D maps in the pontine nuclei, and 3) explore the spatial relationship between corticopontine axons and pontocerebellar neurons.

a. Map transformations in the cerebro-cerebellar system



The essentially 2-D cortical somatotopic map in SI (A) is orderly projected to a more complex 3-D map in the pontine nuclei (B) and further to "fractured" somatosensory representations in the cerebellar hemisphere (C).

b. Experimental procedures

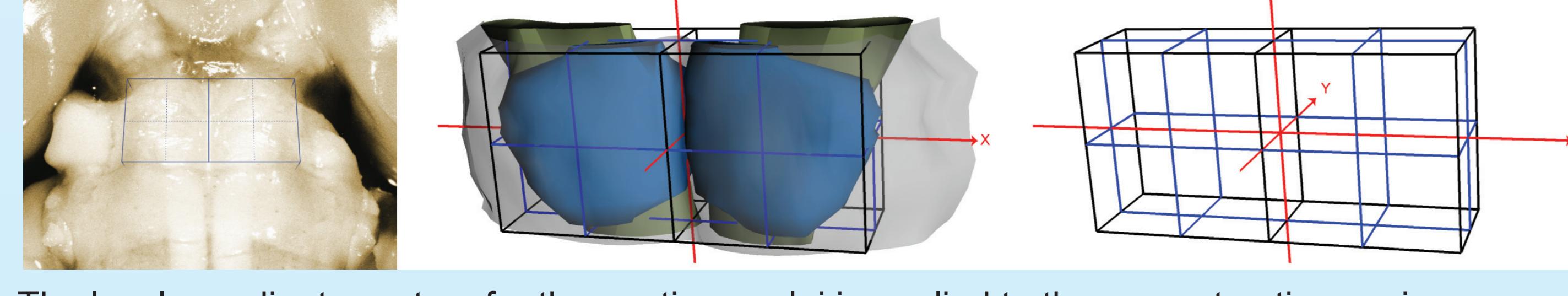


Left: Axonal tracers are applied to the cerebral or cerebellar cortex, giving rise to labeled fibers and cells, respectively, in the pontine nuclei.

Middle: The labeling is visualized in sections through the pontine nuclei, and coded as points, together with lines representing various landmarks.

Right: The digitized sections are aligned and assembled into a 3-D reconstruction.

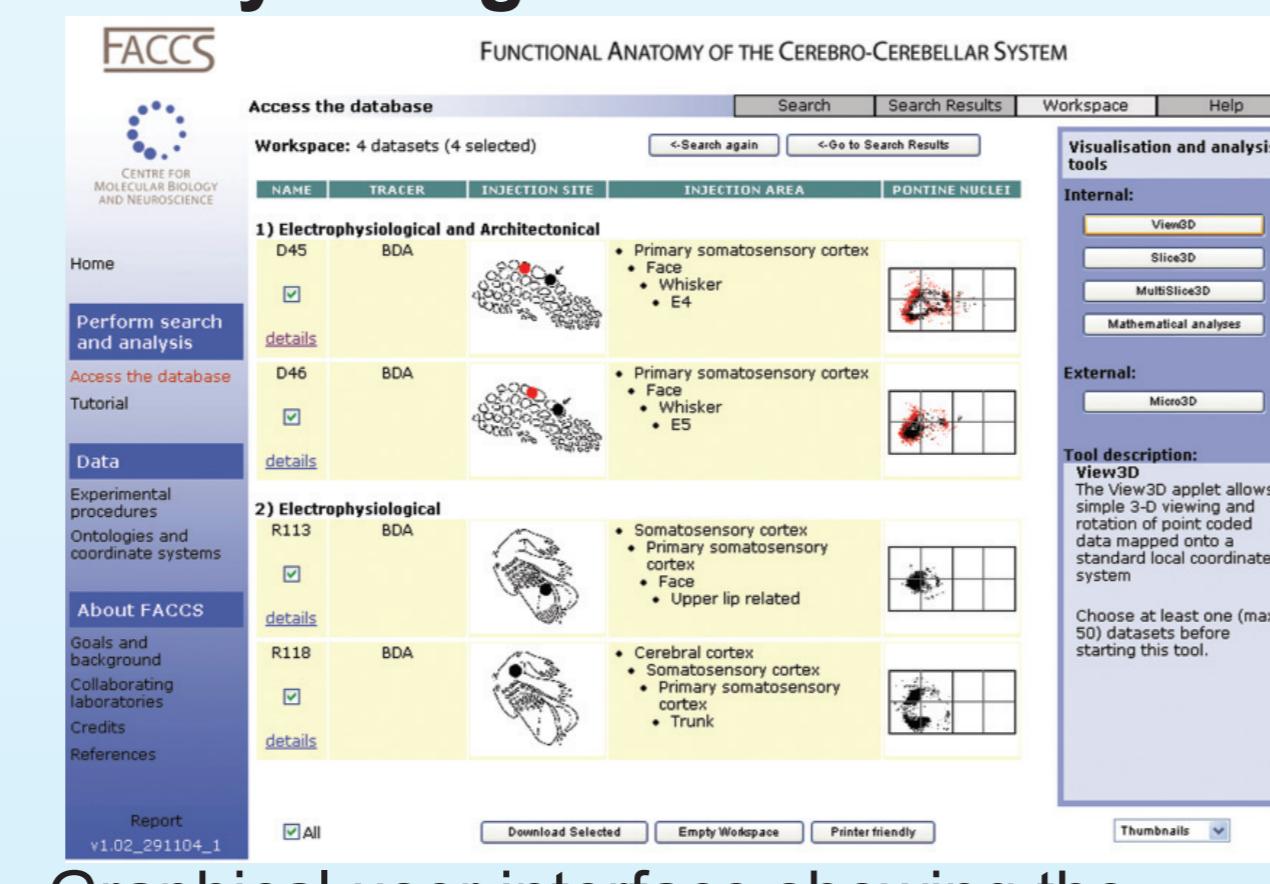
c. Pontine nuclei coordinate system



The local coordinate system for the pontine nuclei is applied to the reconstructions using histological criteria. Data are co-registered to a common spatial framework using affine transformation procedures, and submitted to the FACCS database application.

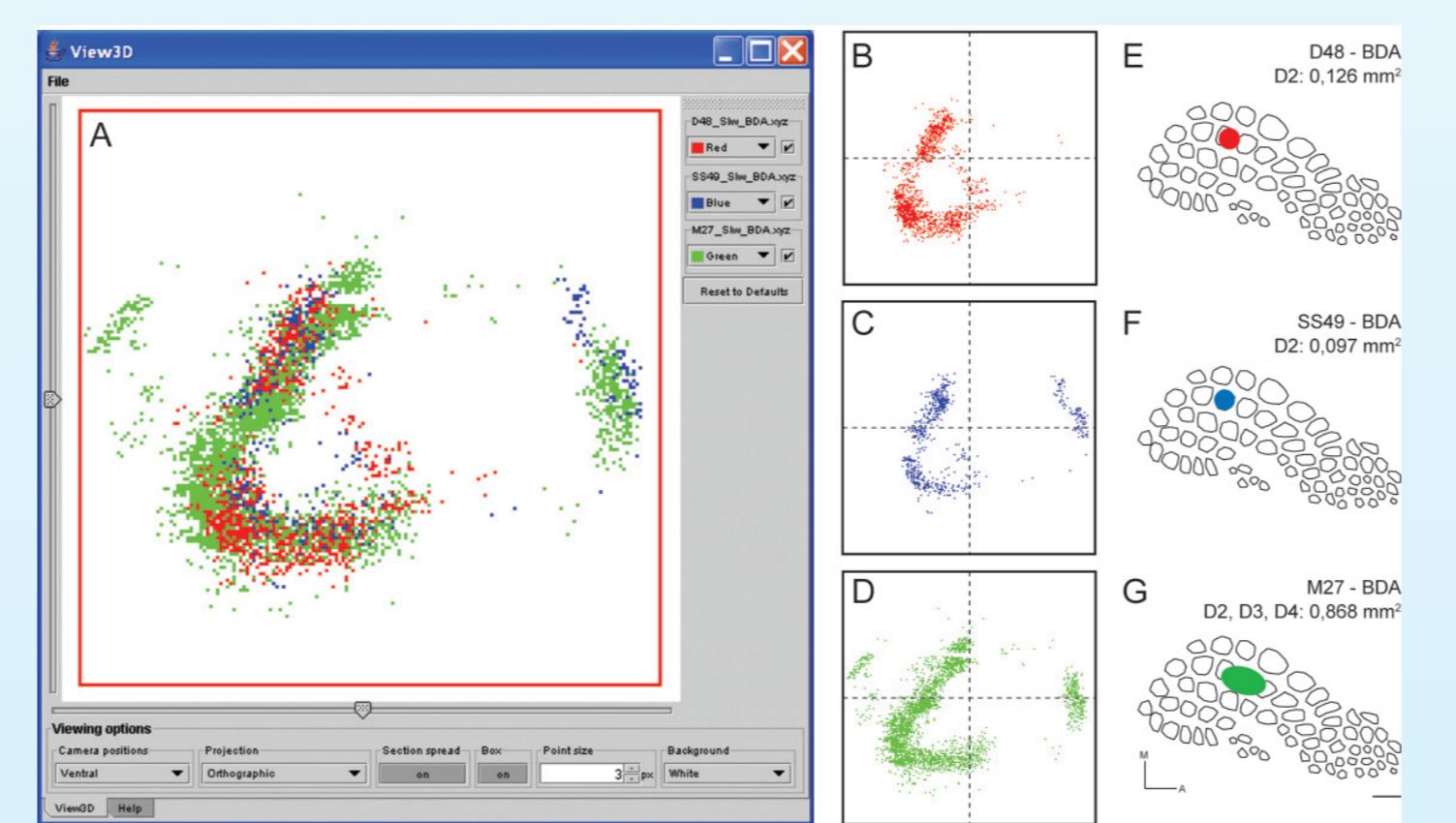
2. METHODOLOGICAL VALIDATION

Query using FACCS



Graphical user interface showing the search results. The search facilities in FACCS are used to identify data sets with similar (SI) injection parameters.

Validation 1

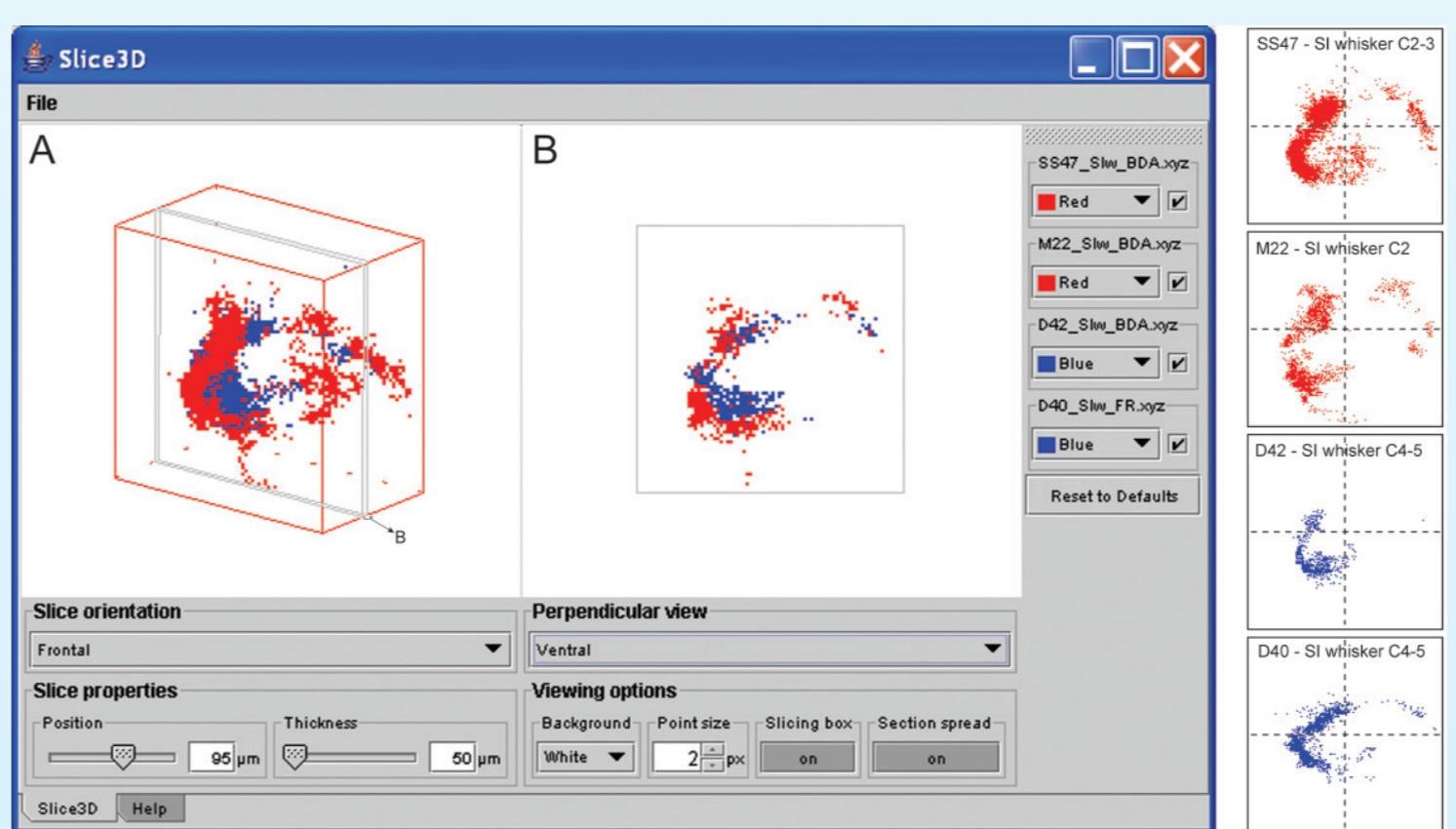


Viewer applet displaying three individual data sets. The similar distributions of labeling (points) result from near identically sized and positioned SI-whisker tracer injections.

Question: Are the results reproducible?

Answer: Yes!

Validation 2



Viewer applet displaying data from four individual tracing experiments. A shift in tracer injection site from high to low SI whisker barrel number corresponds to an internal to external shift in the pontine distribution of labeling, thus reproducing previous dual-tracer results (Leergaard et al., 2000b).

3. TOPOGRAPHIC ORGANIZATION OF SI-CORTICOPONTINE PROJECTIONS

Background

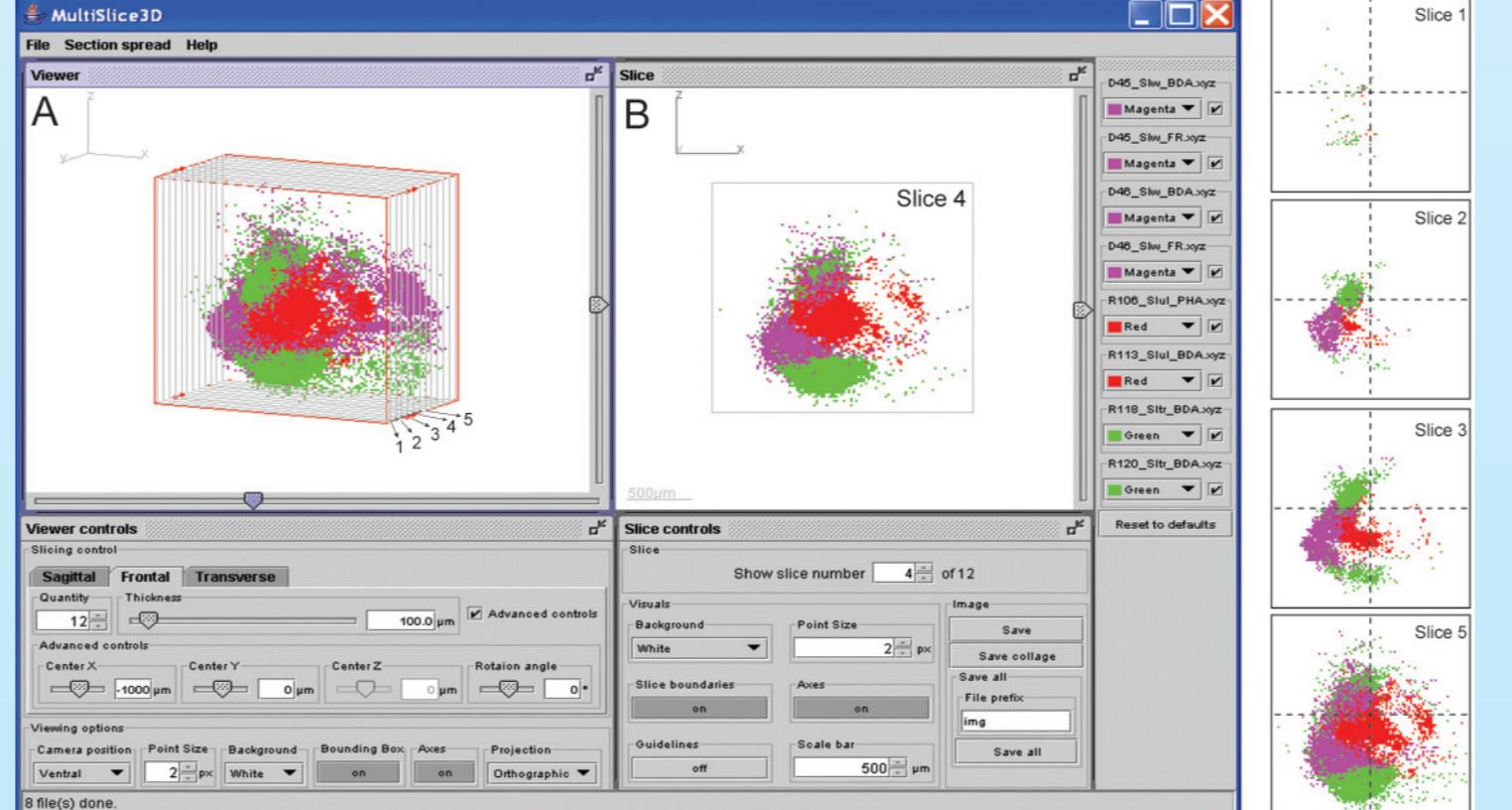
We previously demonstrated a 3-D topographic relationship among SI projections from SI upper lip, trunk, forelimb, and hindlimb representations (Leergaard et al., 2000a).

In two other studies, we investigated the organization of corticopontine projections from individual SI whisker barrels (Leergaard et al., 2000b; 2004)

Here, we use FACCS to combine data from three different investigations to provide a direct comparison of SI whisker projections with projections from SI face and trunk.

After refined search in the database, we selected eight individual datasets for visualization and analysis using digital re-slicing.

Visualization and digital re-slicing



Visualization of eight individual SI corticopontine projection datasets. Digital re-slicing (right column) is used to demonstrate spatially close relationships among projections from SI upper lip (red), whisker (magenta), and trunk (green) representations.

Question:

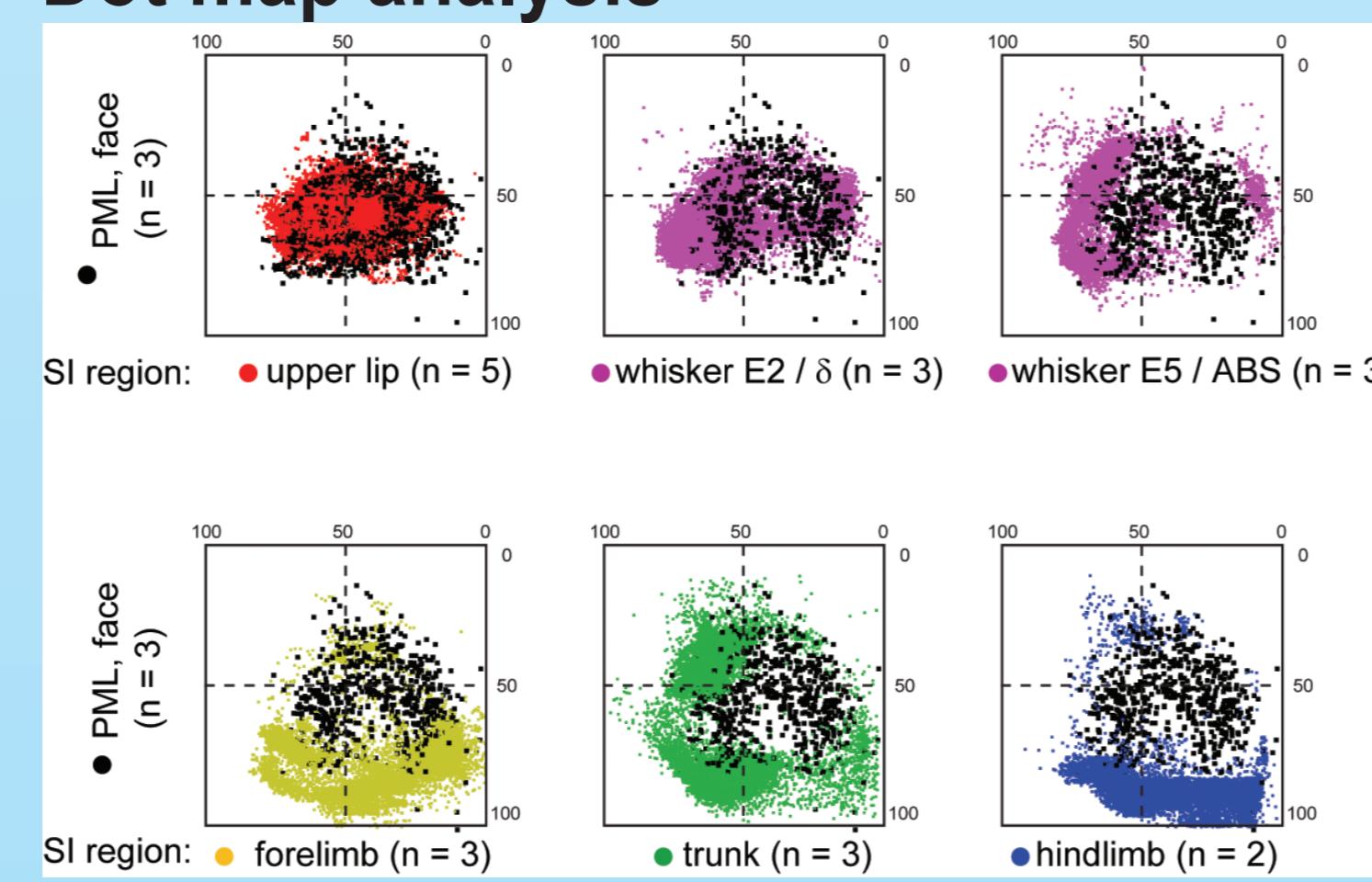
How do SI whisker corticopontine projections relate to projections from neighboring body part representations?

Answer:

SI upper lip, whisker, and trunk projections are topographically distributed, but have close spatial relationships. The spatial proximity of terminal fields is suggestive for pontine integrative properties at several locations.

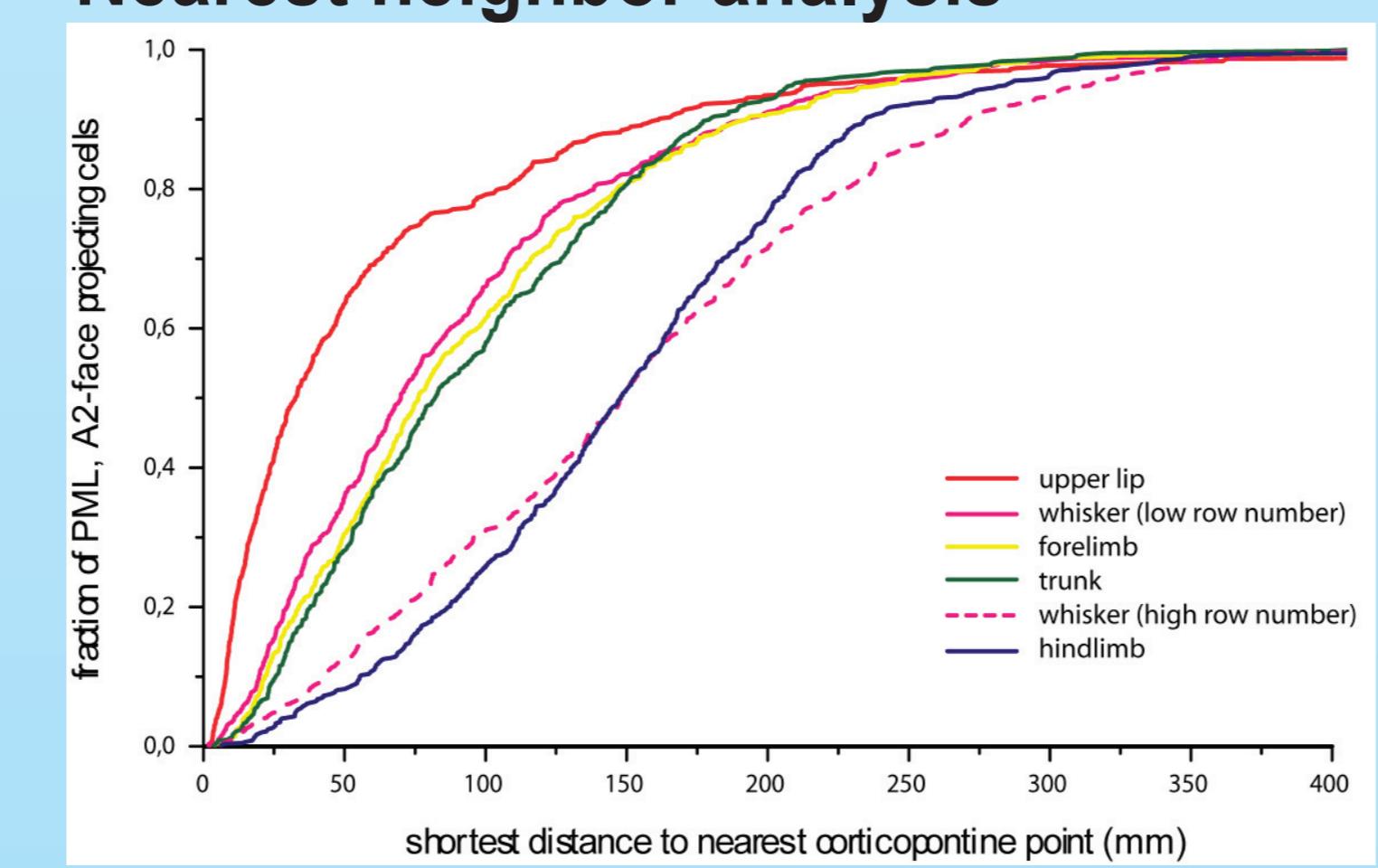
4. CORTICO-PONTO-CEREBELLAR CONGRUENCE

Dot map analysis



Distribution of pontocerebellar neurons projecting to the A2 face region of the paramedian lobule (black dots, three cases) shown together with six different categories of SI cortico-pontine axon clusters. The neuron distribution is apparently congruent with SI upper lip and whisker projections, but also partially overlapping with projections from other SI body representations.

Nearest neighbor analysis



This quantitative comparison (based on data lumped together from multiple animals) shows that the PML face projecting cells are primarily located close to the SI projections originating in upper lip and whisker representations close to the upper lip. With increasing distances from the pontocerebellar cell bodies, proximity to other SI projections is also observed.

Question:

Odeh et al. (2005) demonstrated congruence of pontine projections to the face-receiving zones in cerebellar paramedian lobule (PML) and face-related SI-pontine projections. How do pontocerebellar neurons relate to SI projections from other body representations?

Answer:

The strongest spatial association is found among PML projecting neurons and axons arising from the SI upper lip representation. However, proximity to projections from other SI representations is also seen.

This finding is compatible with integration of somatosensory signals in the pontine nuclei.

5. SUMMARY AND CONCLUSIONS

We here demonstrate that in computo experiments provide reproducible results and that accumulation of published data in a database provides novel opportunities for testing multiple interpretations of data distributions. This approach, in turn, allows better planning of future experiments.

We further demonstrate potential integrative properties of the pontine nuclei:

Corticopontine projections from different aspects of the SI somatotopic body map are topographically organized, but do also have close spatial relationships at several locations in the pontine nuclei.

Pontocerebellar neurons projecting to the A2 face representation in the paramedian lobule, are distributed in close proximity to pontine afferents from SI upper lip and whisker representations. Pontine projections from other SI body representations are distributed at gradually increasing distances.

MORE INFORMATION

URLs: www.rbwb.org / www.nesys.uio.no
To contribute data, please contact j.g.bjaalie@medisin.uio.no

PDF copy of poster is available at www.nesys.uio.no

Database technical solutions are presented at poster 687.15 on Tuesday Nov 15, AM at board WW8

Related publications:

- Leergaard et al. (2000a) J Comp Neurol 422:346-266
- Leergaard et al. (2000b) J Neurosci 20:8474-8484
- Leergaard (2003) Anat Embryol 206:149-162, 2003
- Leergaard et al. (2004) J Comp Neurol 478:306-322
- Odeh et al. (2005) J Neurosci, 25:5680-90
- Bjaalie et al. (2005) Neuroscience, In Press

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