### Dendrogram processing for whole-brain connectivity-based hierarchical parcellation





### Declaration of Relevant Financial Interests or Relationships

David Moreno-Dominguez:

I have no relevant financial interest or relationship to disclose with regard to the subject matter of this presentation.

### **Estimation of Anatomical Connectivity**



#### ... using diffusion weighted MRI and tractography.

Heidemann, Anwander, Feiweier, Knösche, Turner, NeuroImage 2011

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## **Connectivity-Based Parcellation**



Tractographic Fingerprints

Probabilisitic tractography





Knösche & Tittgemeyer, Front Syst Neurosci 2011

### Limitations

#### **Target-based Parcellation**

- Strong assumptions each parcel should be mainly connected to one target area.
- Target areas maybe difficult to delineate.

#### **Free Clustering**

- Number of clusters, average size of clusters, or similar need to be known in advance  $\rightarrow$  model selection problem.
- Parcellation is assumed to be unique and complete  $\rightarrow$  boundaries may be fuzzy and there may be outliers.

# **Agglomerative Hierarchical Clustering**

- Starting with seed points (leaves), a new element is created by joining the two most similar elements.
- New distances from the new nodes to the other ones are obtained
- Operation is iterated until only one element remains



### **Tree Quality Assessment**

How similar the distances encoded in the tree are to the distances measured directly from the tractograms?

#### $\rightarrow$ cophenetic correlation coefficient (0.0 ... 1.0)



### **Preprocessing – Tree Simplification**



### **Assessment of Hierarchical Tree**

- In order to map tree information back to the cortex, the most important information has to be selected.
- In most cases, the similarity structure is best represented by a series of partitions.



• Partitions are collections of unnested nodes.



• There are different possible criteria for selecting partitions.



Parcellation by joining distance (biggest distance between any pair of subclusters)





Detecting most distinct boundaries (distance to next > 10% of tree height)

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### **Tree Comparison**

#### **Cophenetic similarity**



- Distance values at which all possible pairs of leaves join
- → Emphasis on numerical distance values

#### **Triples similarity**



- Joining order of all possible triples of leaves
- → Emphasis on tree topology

### **Tree Comparison**



### Conclusions

- Structural (and functional) feature maps are generally smooth with occasional (frequent?) sharp transitions.
- Parcellations are approximations of these maps at a given granularity level.
- Hierarchical trees capture the similarity structure of feature maps in a more complete way.
- Trees cannot be mapped on the cortex, therefore they should be interpreted by means of series of relevant partitions.
- For comparison of mappings, the entire trees should be used.

### Outlook

- Finding the most relevant partitions within a tree
- Identifying consistent partition levels across subjects
- Validating results:
  - Data from repeated measurements
  - Study with 6 pairs of identical twins





### Thank you

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