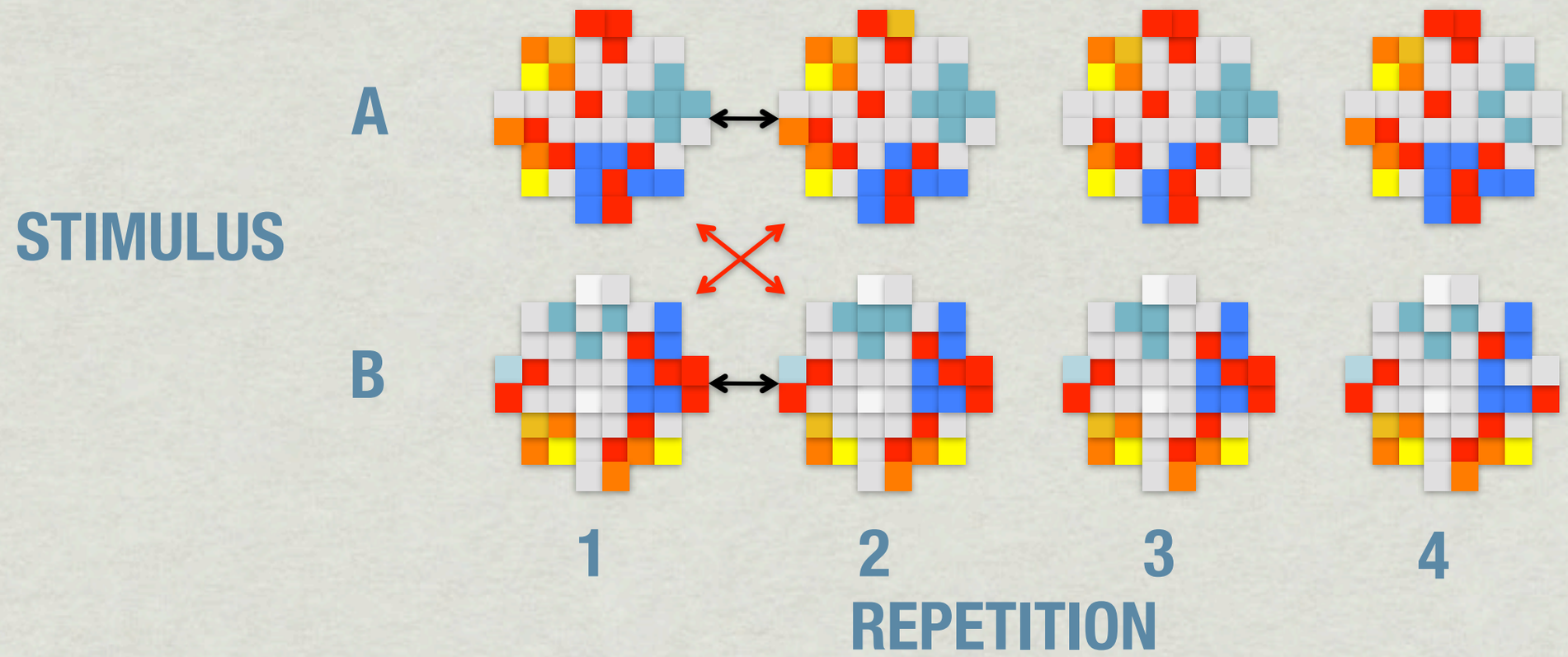
Method 2: distance measures

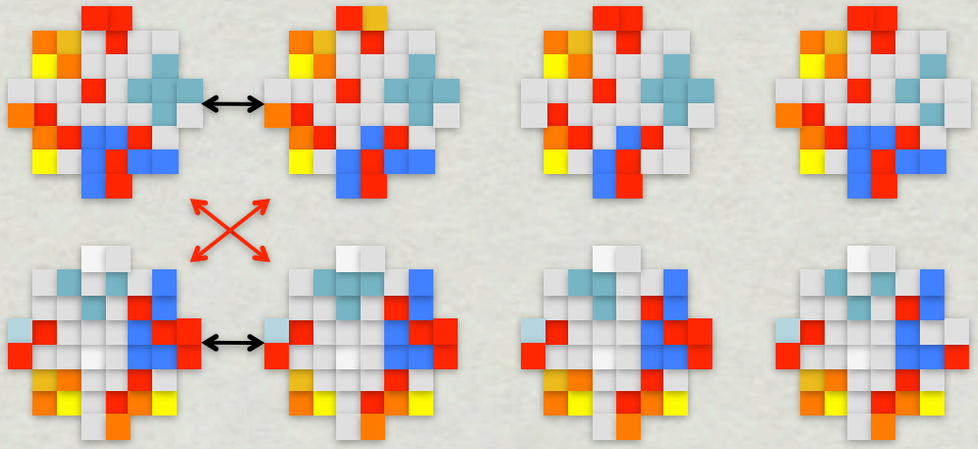


- Distance measures: correlation (pearson or spearman); mahalanobis; euclidian difference

STIMULUS

A

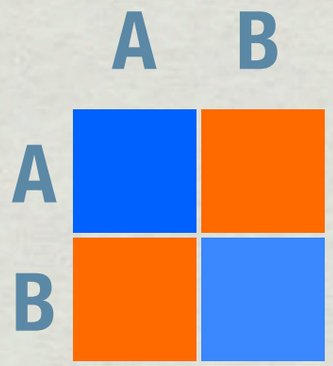
B



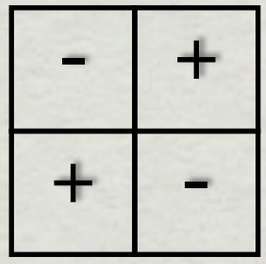
1 2 3 4

REPETITION

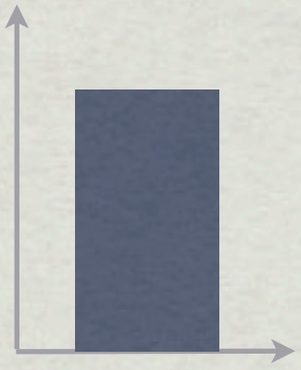
REPRESENTATIONAL (DIS)SIMILARITY MATRIX (RDM)



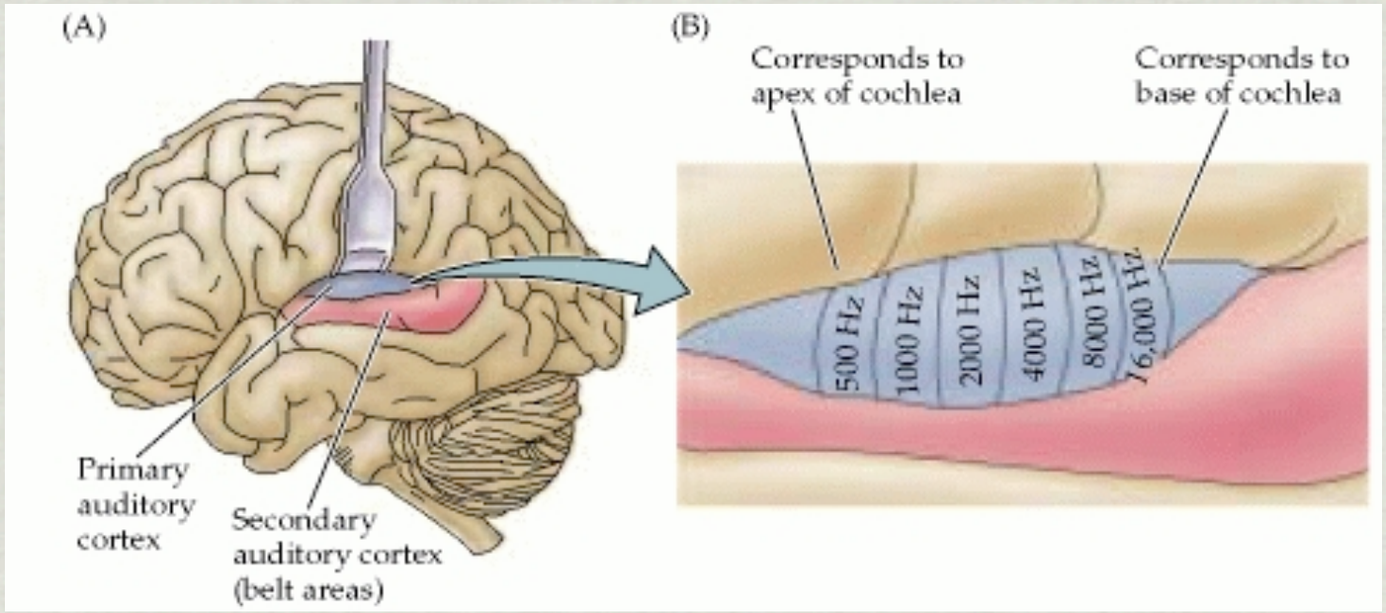
MVPA CONTRAST



MEASURE OF OF A VS. B CODING



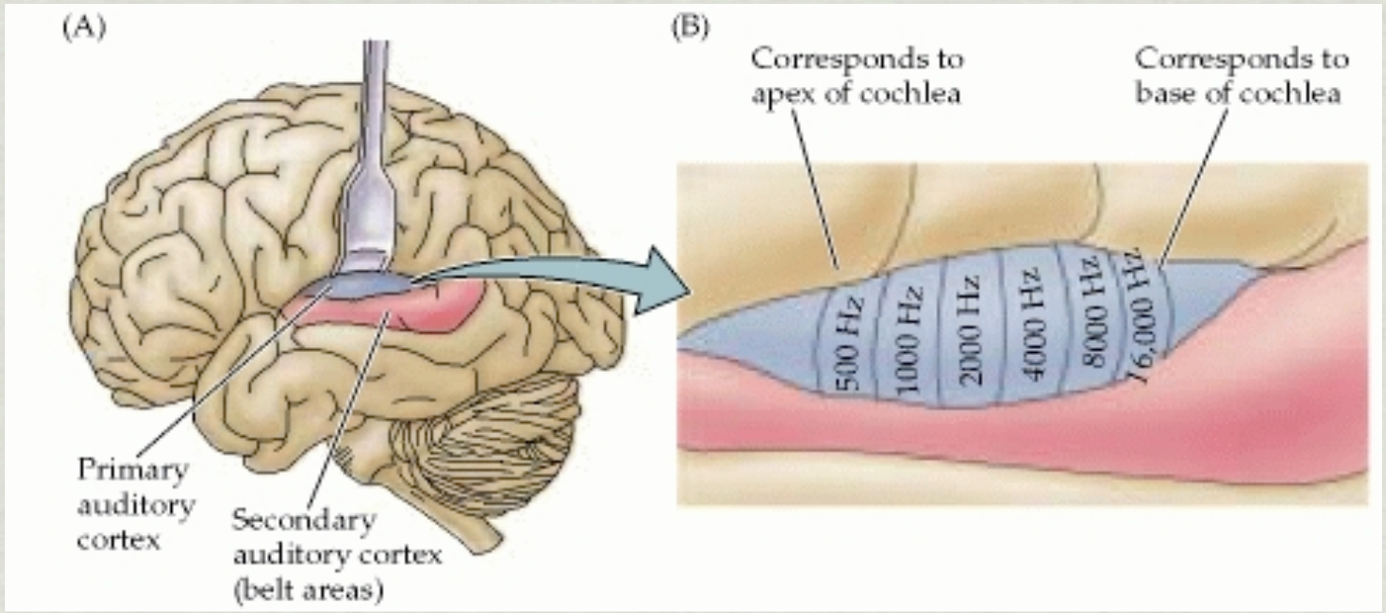
Tonotopy



TEXTBOOK

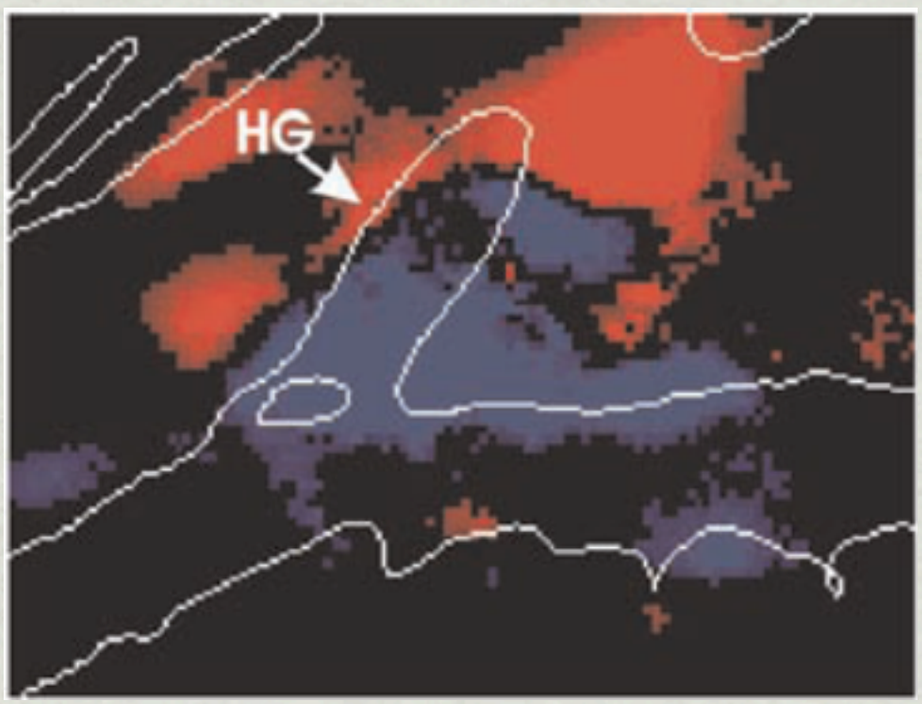
STATE-OF-THE-ART FMRI

Tonotopy

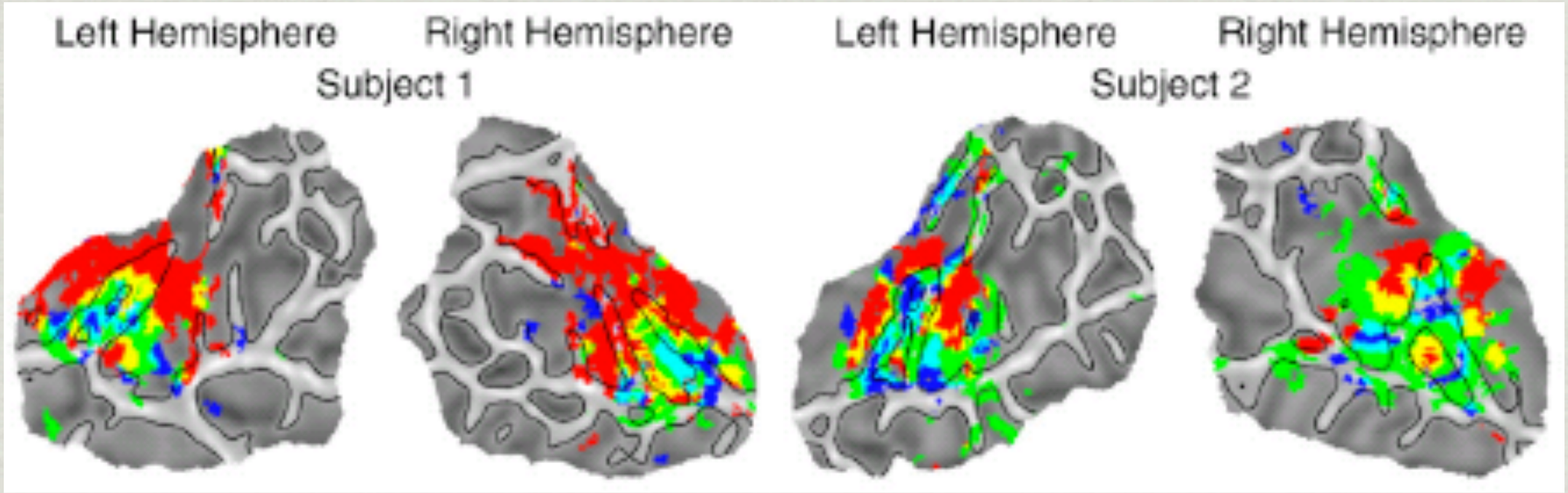


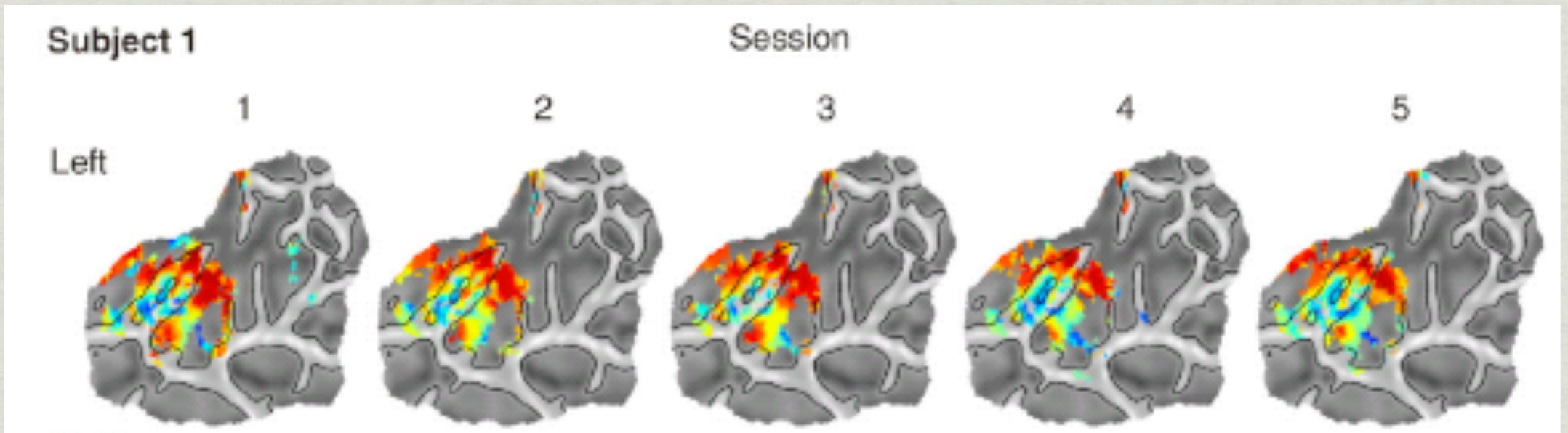
TEXTBOOK

STATE-OF-THE-ART FMRI

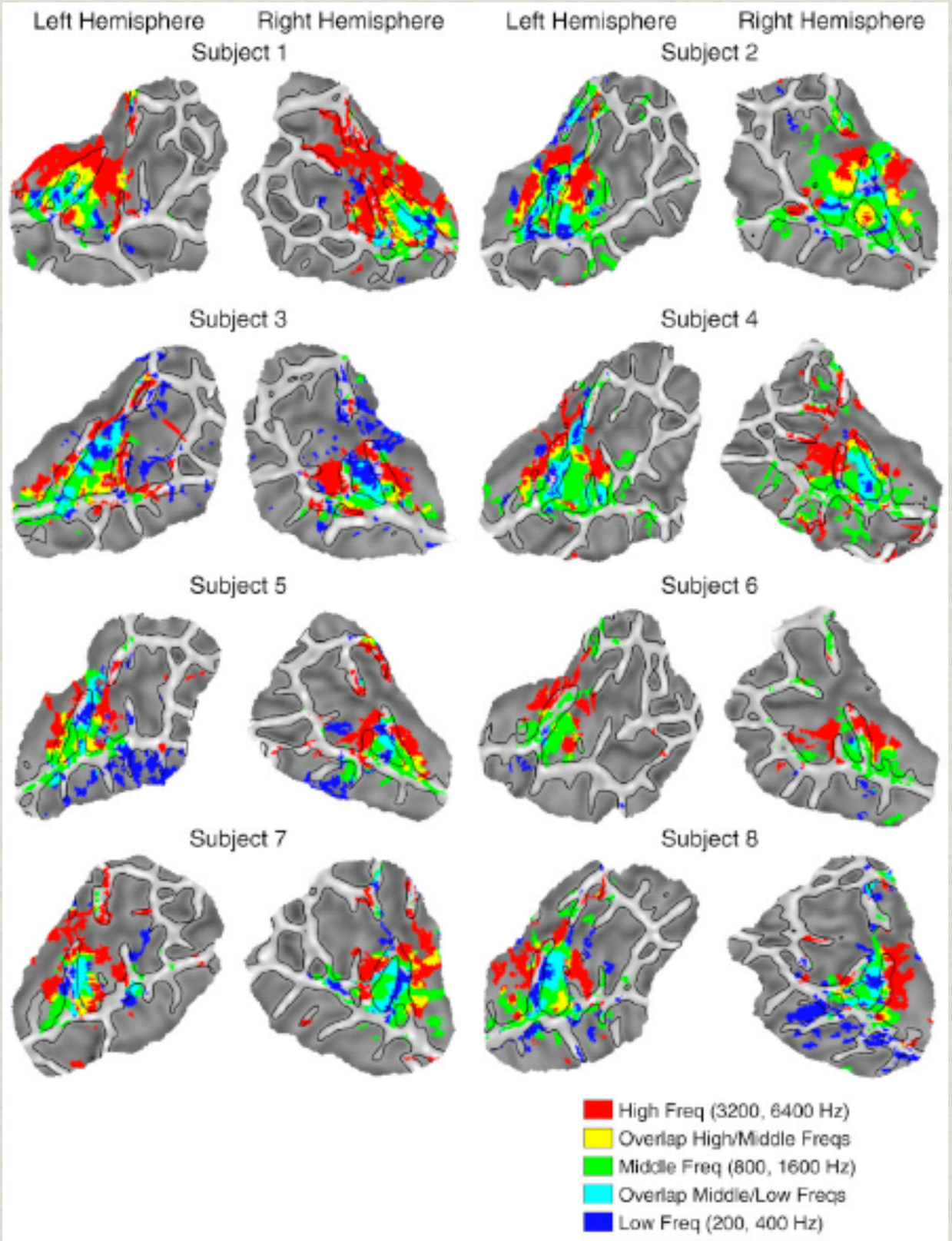


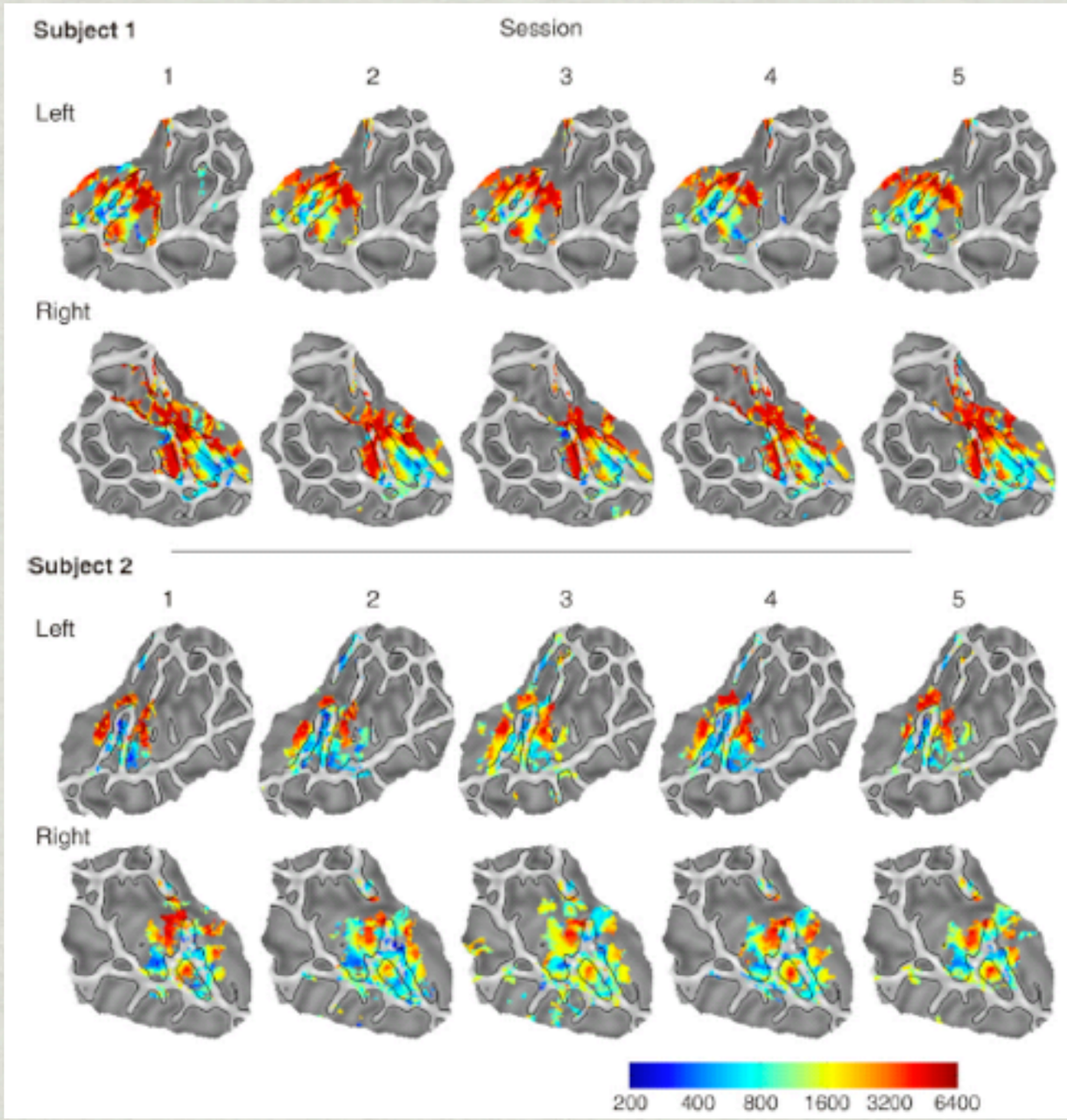
Individual differences in tonotopy





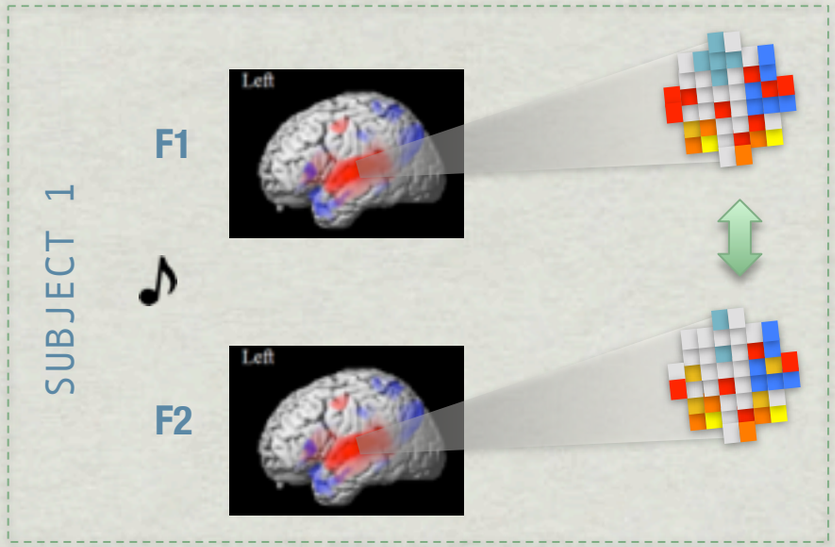
HUMPHRIES ET AL (2010)

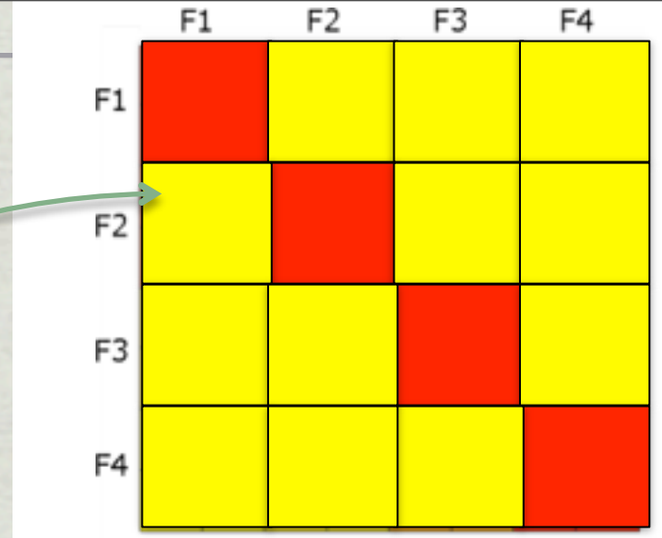




HUMPHRIES ET AL (2010)

MVPA OF TONOTOPY





SIMILARITY OF PATTERNS FROM SAME-DIFFERENT FREQUENCIES

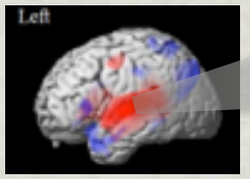
LINKE ET AL (2011)

...

MVPA OF TONOTOPY

SUBJECT 1

F1



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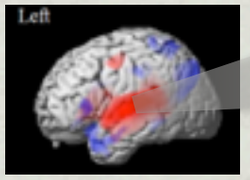

SUBJECT 2

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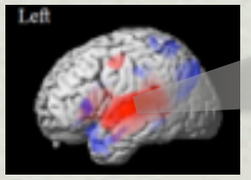

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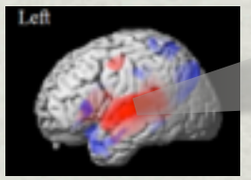

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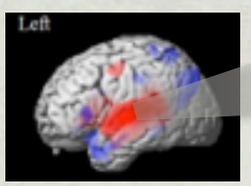

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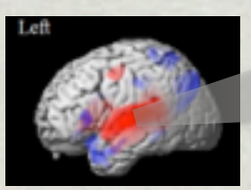

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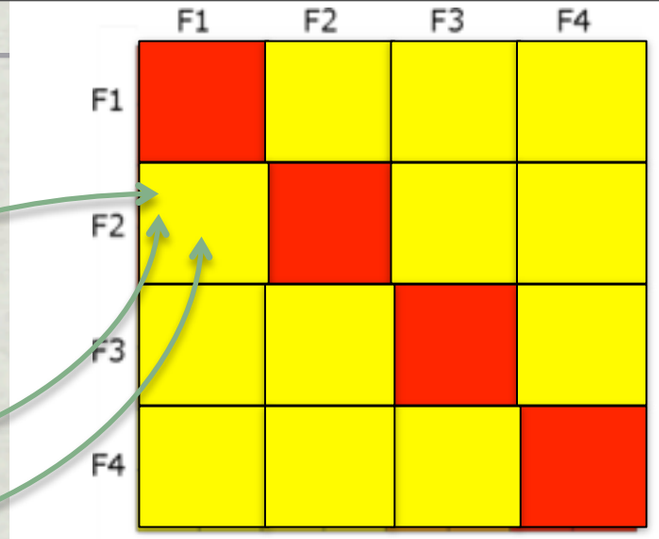


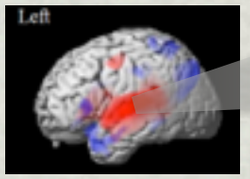
SIMILARITY OF PATTERNS FROM SAME-DIFFERENT FREQUENCIES

LINKE ET AL (2011)

MVPA OF TONOTOPY

SUBJECT 1

F1



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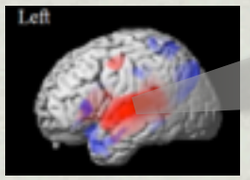

SUBJECT 2

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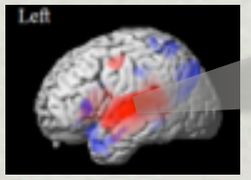

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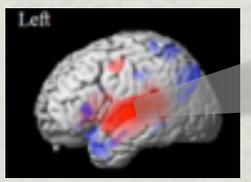

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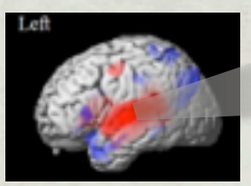

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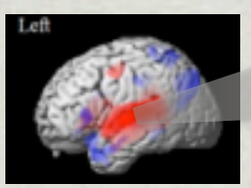

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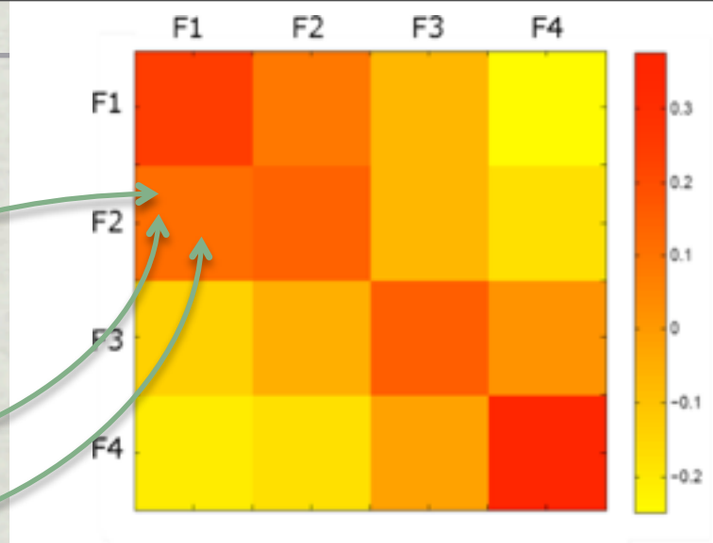


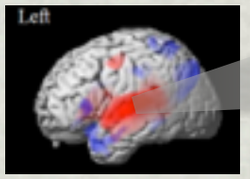
SIMILARITY OF PATTERNS FROM SAME-DIFFERENT FREQUENCIES

LINKE ET AL (2011)

MVPA OF TONOTOPY

SUBJECT 1

F1



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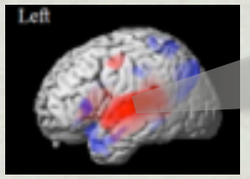

SUBJECT 2

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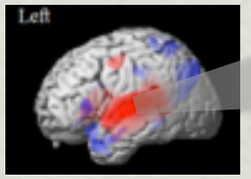

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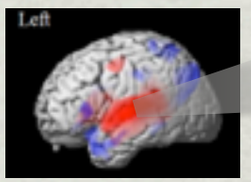

SUBJECT 3

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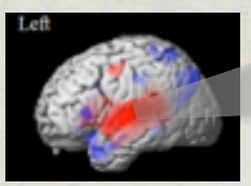

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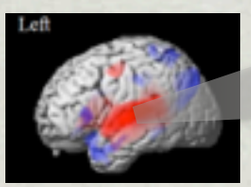

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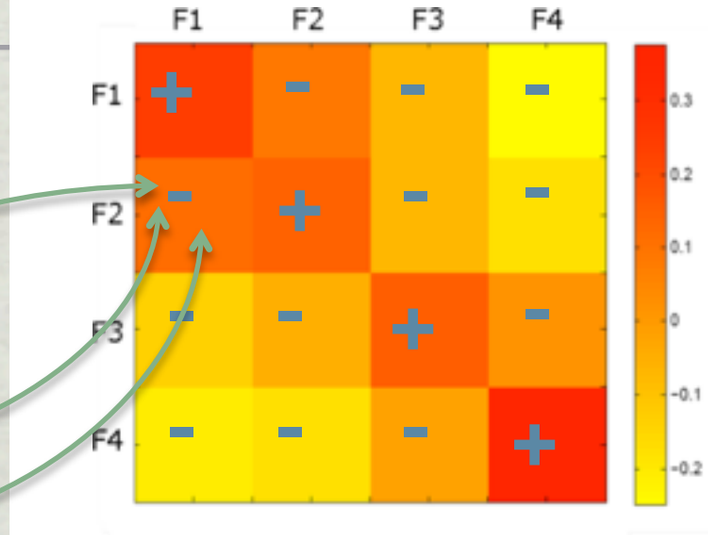

SIMILARITY OF PATTERNS FROM SAME-DIFFERENT FREQUENCIES

LINKE ET AL (2011)

MVPA OF TONOTOPY

SUBJECT 1

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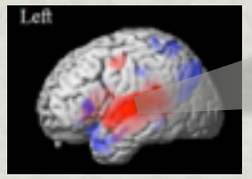

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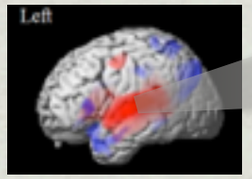

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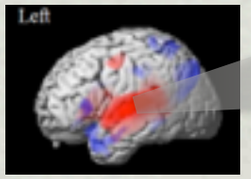

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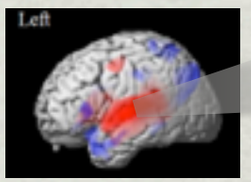

SUBJECT 3

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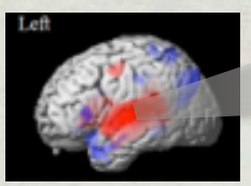

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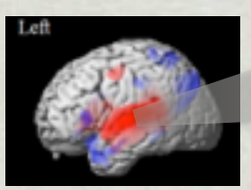

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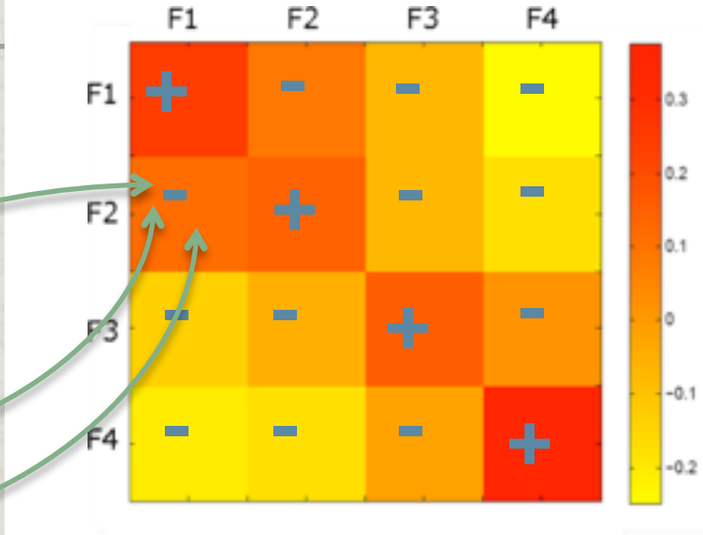
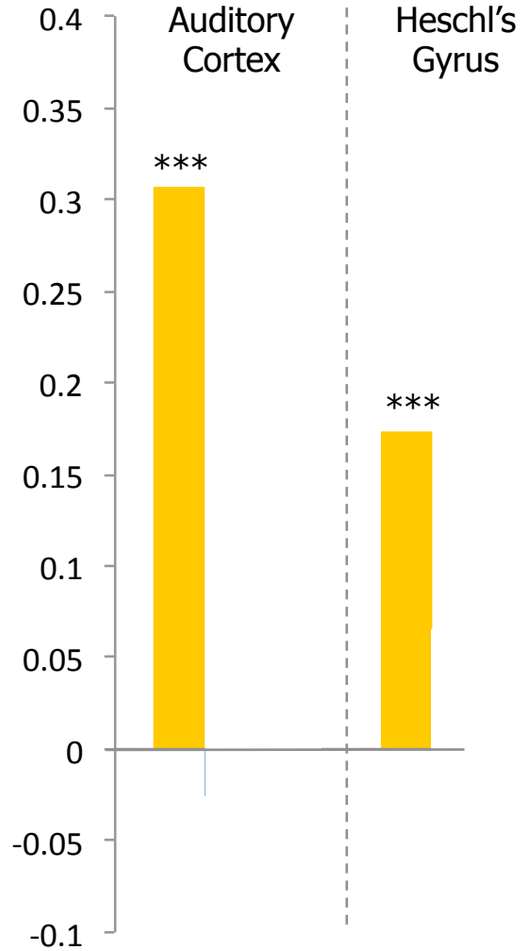
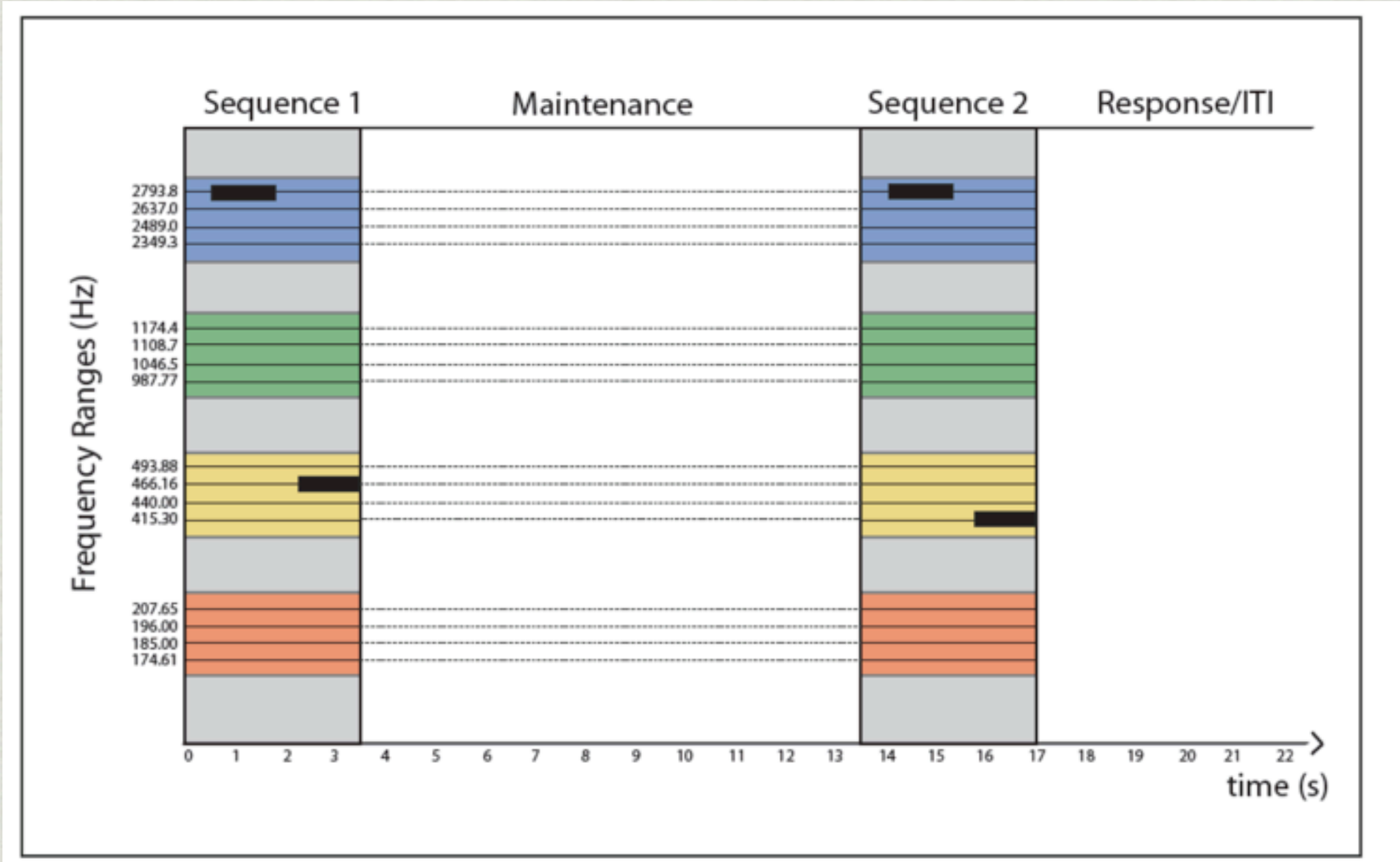


SIMILARITY OF PATTERNS FROM SAME-DIFFERENT FREQUENCIES



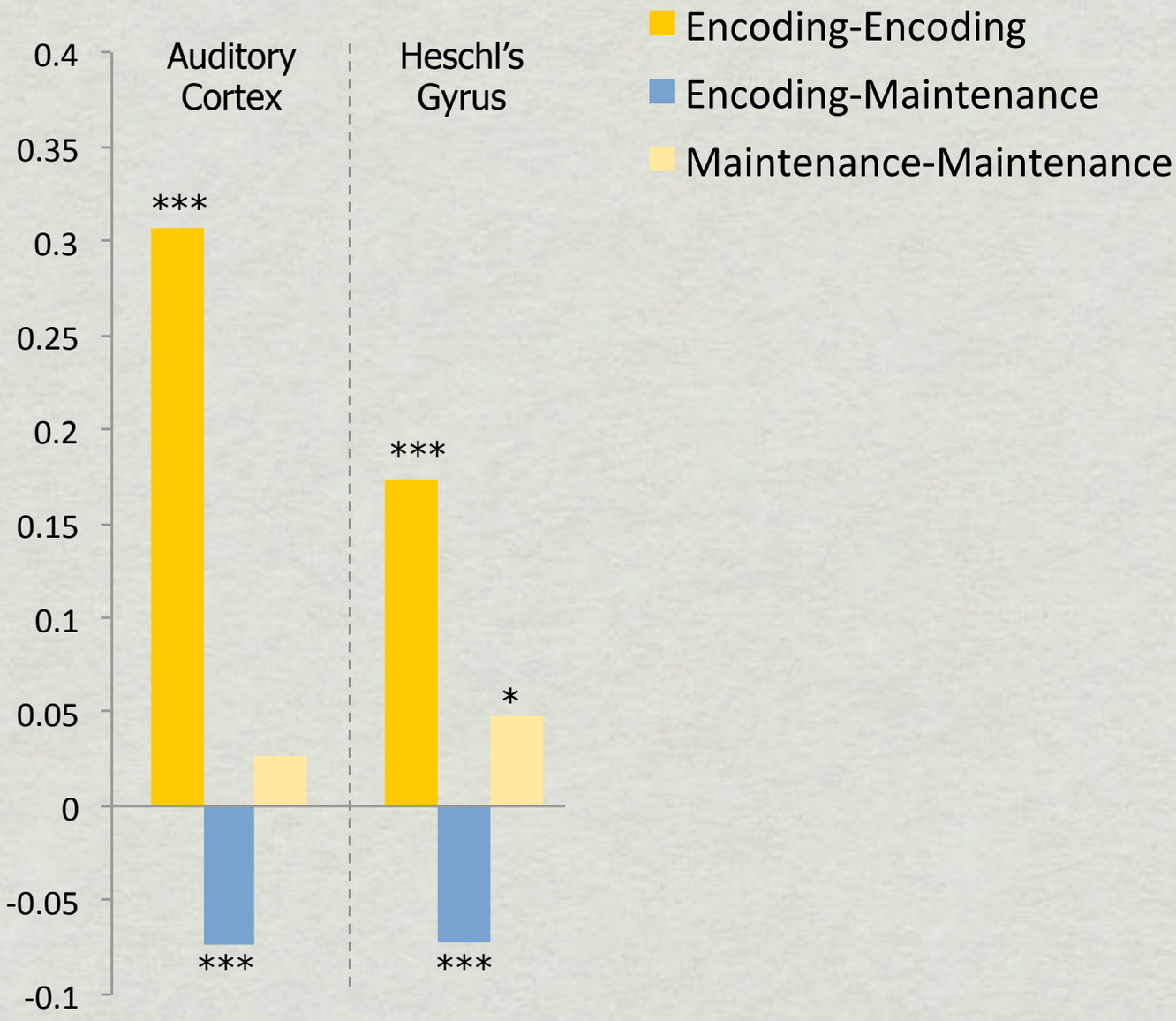
LINKE ET AL (2011)

Auditory short-term memory



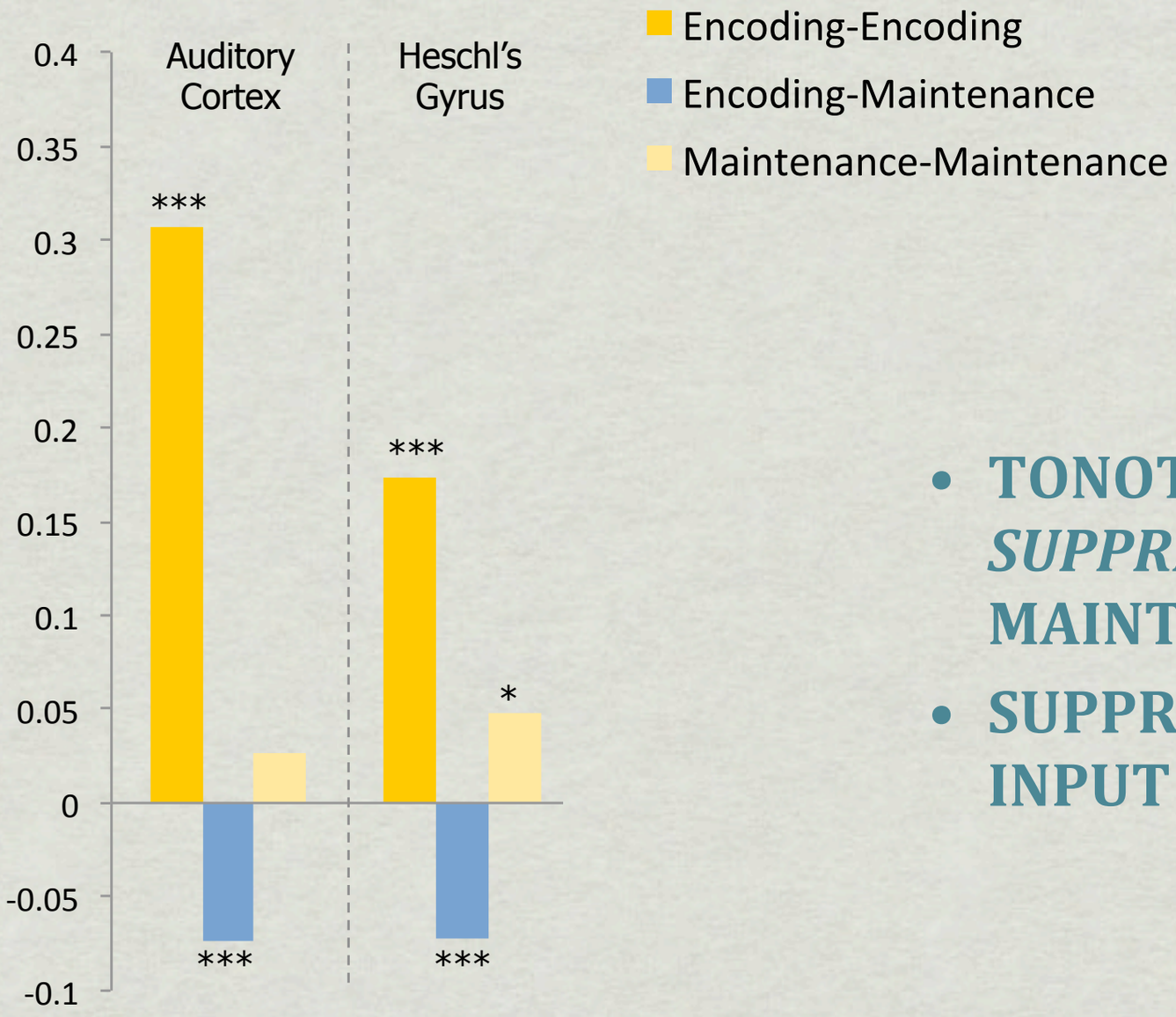
LINKE ET AL (2011)

Tonotopy during auditory short-term memory



LINKE ET AL (2011)

Tonotopy during auditory short-term memory

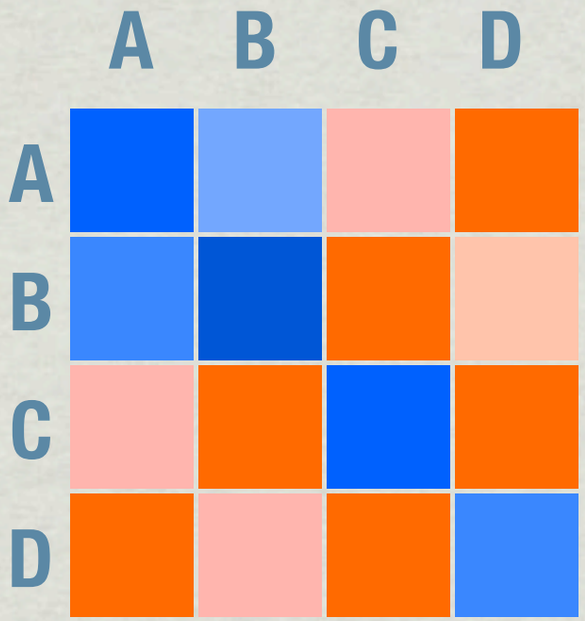


- **TONOTOPIC *SUPPRESSION* DURING MAINTENANCE PERIOD**
- **SUPPRESS SENSORY INPUT**

LINKE ET AL (2011)

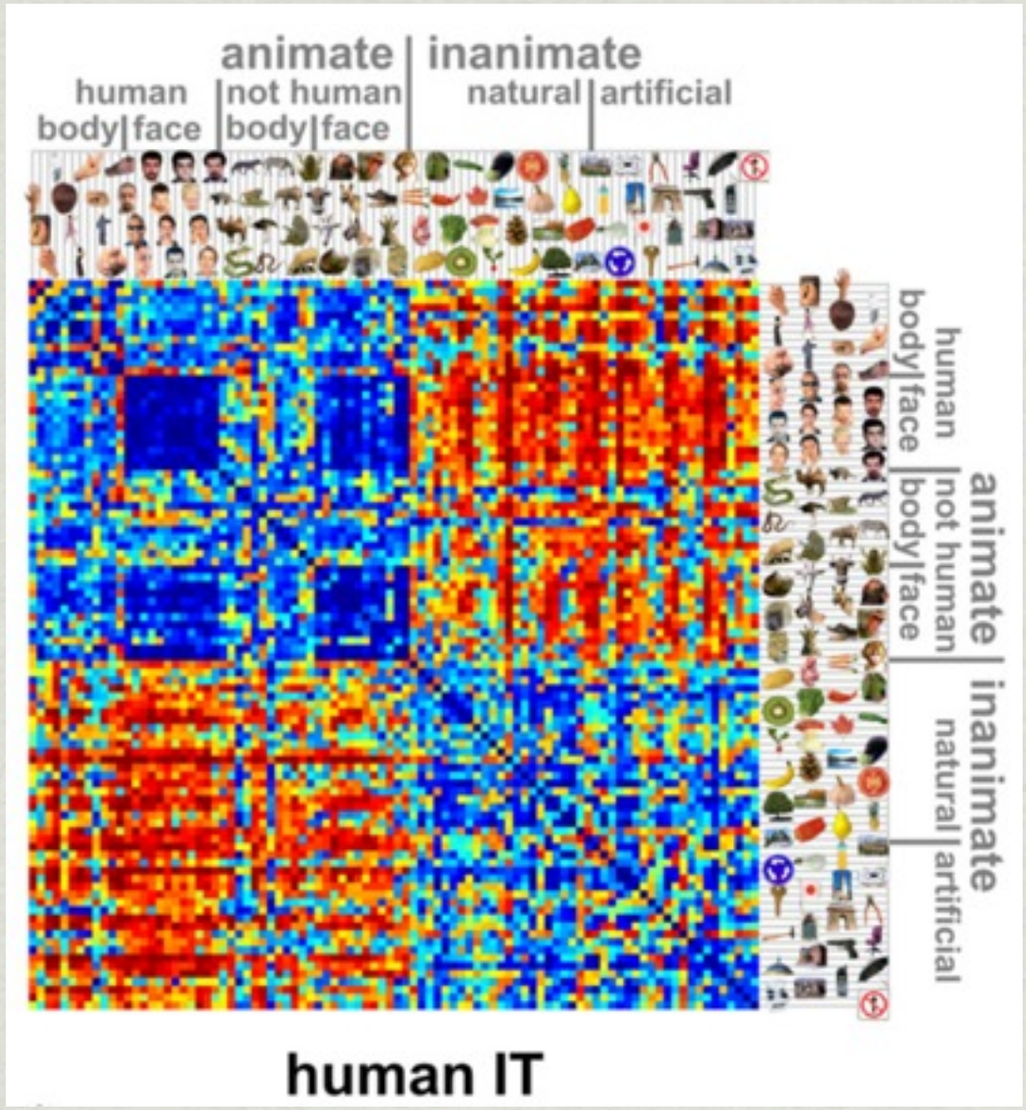
Method 3: MDS

REPRESENTATIONAL (DIS)SIMILARITY MATRIX (RDM)

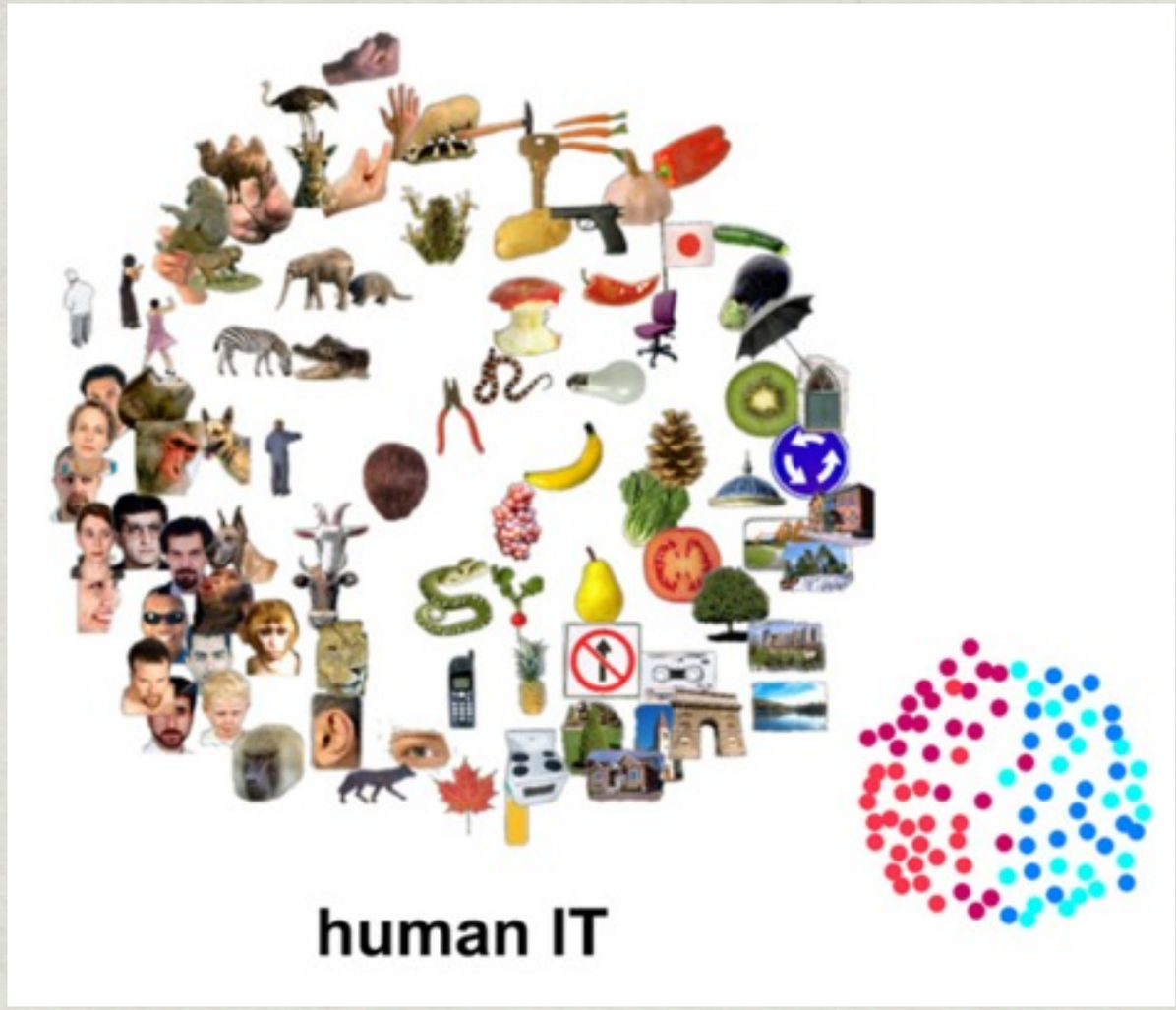


MULTI-DIMENSIONAL SCALING

Method 3: MDS



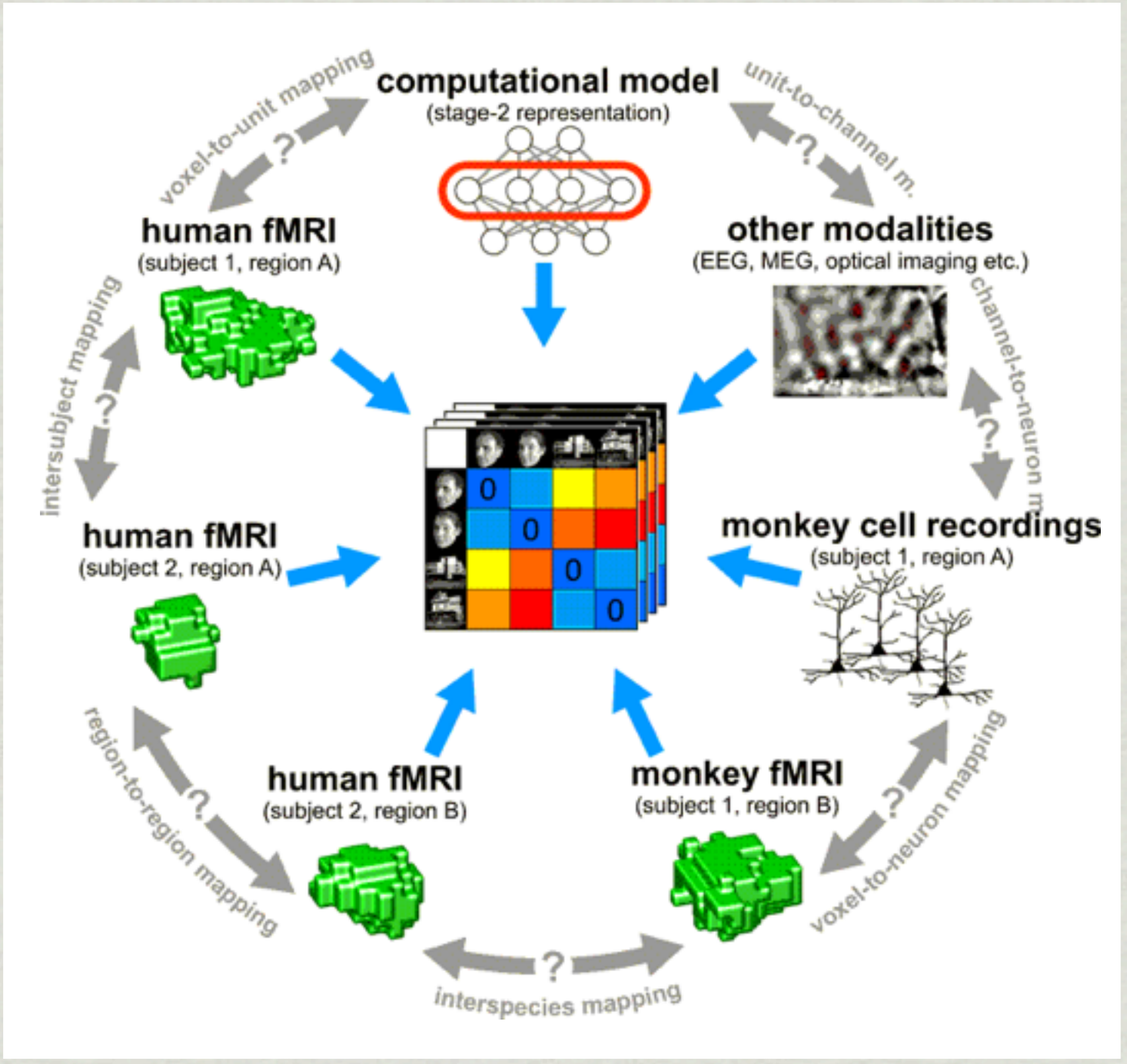
RDM



MDS

KRIEGESKORTE ET AL (2008)

Using RDMs to relate branches of neuroscience



KRIEGESKORTE (2009)

Which method?

- *If exploratory analysis with complex stimulus set:*
  -MDS allows the visualization of the coding space.

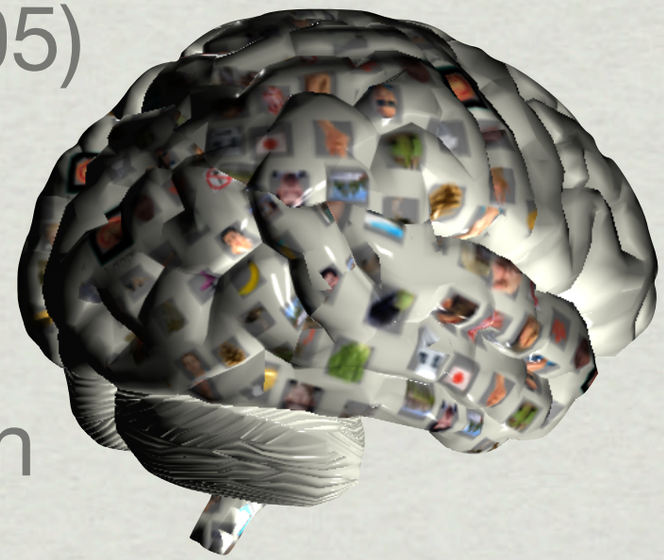
- *If coding is non-linear...*
  -Use non-linear classifier. But, non-linear classifiers often don't perform any better than linear ones (e.g., Misaki et al, 2010) and are much harder to interpret (Anderson et al, Cog Sci 2010)

- *Otherwise*
  Use a distance measure such as correlation or a linear classifier (linear SVM, LDA). Simple and effective!

ROI vs. searchlight

- MVPA examines the patterns with a region
- Occasionally, for practical applications, this can be the whole brain (Davatzikos et al., 2005)
- For cognitive neuroscience, it is:
  - a set of *a priori* regions
  - a searchlight, swept around the brain

  (Kriegeskorte et al, 2006)



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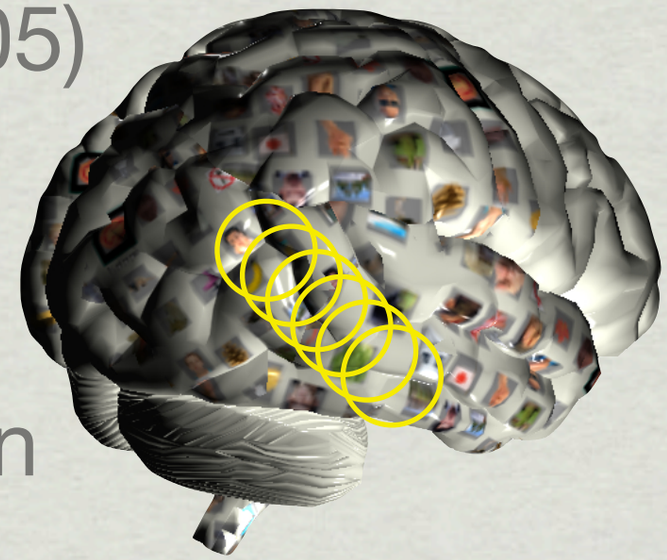
  - a searchlight, swept around the brain

  (Kriegeskorte et al, 2006)



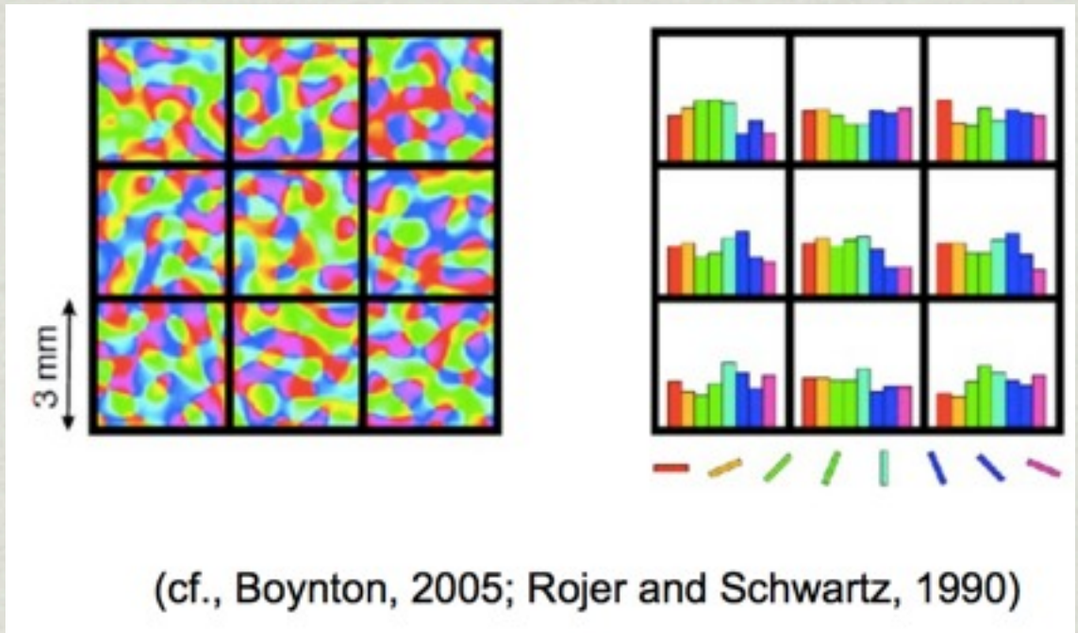
Constraints & limitations

- Reminder: absence of an effect in a region does not mean it does not code that feature

- Be careful about concluding what drives your signal
  - Most methods are sensitive to univariate signal to some extent
  - Can be elegant to make MVPA & univariate analyses orthogonal (e.g., MVPA invariant to mean signal in ROI; univariate done on ROI)
  - Higher resolution isn't always better (Brants et al, 2011; Thompson et al, 2011) but it can be (Thompson et al, 2011; Swisher et al, 2010)

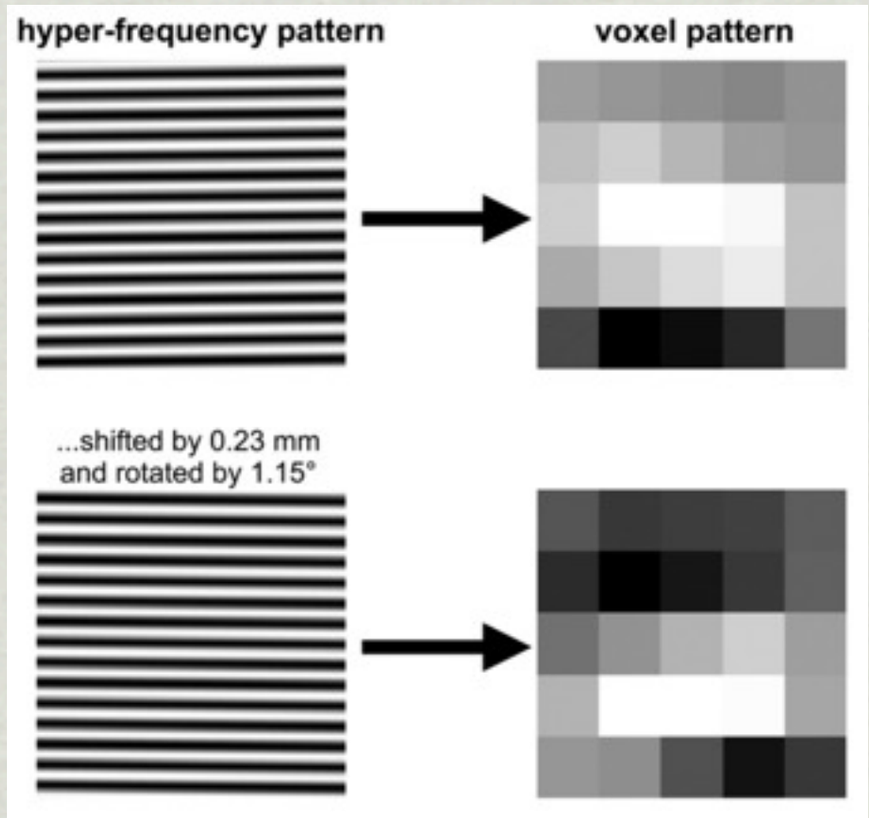
Constraints & limitations

- MVPA cannot see information at a scale finer than the smallest of: (1) your voxel size; (2) the subject motion



HYPER-FREQUENCY THROUGH ALIASING?

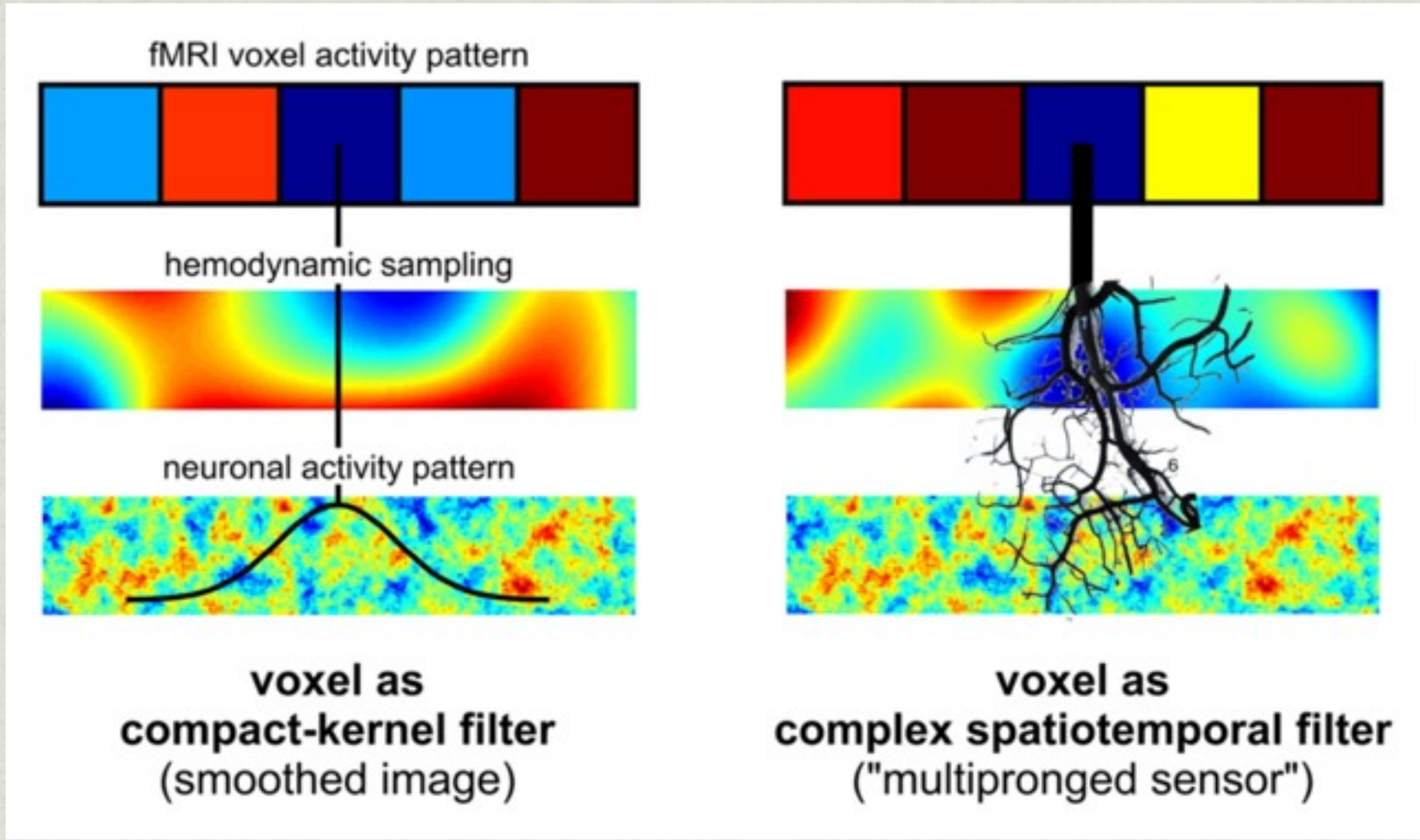
NO: SUBJECT MOTION WILL SCRAMBLE ALIASING



KRIEGESKORTE, CUSACK, BANDENTTINI (2010)

Constraints & limitations

- Blood vessels will displace and may change the form of the MVPA signal (for better or for worse)



KRIEGESKORTE, CUSACK, BANDENTTINI (2010)

Constraints & limitations

- There is a lot of hype surrounding MVPA
  - mind reading, decoding, encoding

- Ultimately, just trying to connect brain data to models. The same descriptions could be equally applied to univariate data.

- Can be a useful way of thinking about what we're trying to do, but can also be a big distraction, and excessively grandiose claims may bring disrepute on the field.

Summary

- MVPA is a powerful addition to fMRI methods, especially for
  - distributed representations
  - poor inter-subject alignment

- Many methods are available. The simplest often work as well as more complicated methods that are harder to interpret
  - distance measures; linear & non-linear classifiers; MDS

- Works it practice, revealing information invisible to univariate analyses. Many potential applications.