MVPA – *Representation: How is information represented in different brain structures; how is that information transformed?*

1. Issues with traditional analysis:
   1. Weak responses may carry information, but traditional analysis ignores them
   2. Spatial averaging blurs the fine-grained “patterns” of activity
   3. Goal of boosting sensitivity Signal to noise Ratio by using many voxels, without losing signal by averaging or ignoring weak responses.
   4. Traditional group analysis requires averaging across subjects
2. Advantages of MVPA:
   1. Can identify the neurons that represent a specific property of a stimulus
   2. Can identify the cognitive state that a participant is in
   3. Pattern presence or absence can appear/disappear over a timescale of seconds, for example in binocular rivalry
3. Pattern Classifiers: Quantifying how well a region represents a process
   1. Feature selection -> pattern assembly (training) -> classifier
   2. Linear vs. non-linear patterns (univariate analysis *cannot* capture nonlinear effects)
      1. Linear tells us that some of the voxels we chose are individually sensitive to the dimension of interest, therefore the information is explicit in the input.
      2. Non-linear has no constraints: but this means we cannot be sure whether the information is contained in the classifier weights (implicit in the input) or explicitly in the input.
   3. Small irregularities in voxel contents can, when averaged across the voxel, appear as a ‘pattern’ of activity. The actual information is sub-voxel, but the pattern is super-voxel, which allows the classifier to pick up on it.
4. Downsides:
   1. Using classifier ‘weights’ depends on the method chosen, and tend to represent the most discriminative voxels—not necessarily the voxels that responded most to a category. Shared information is discarded.
   2. MVPA results are very difficult to interpret…

fMRI-A –

1. Repetition suppression as a way of inferring knowledge about representations:
   1. Specifically: by measuring suppression that occurs for repeated stimuli, against repeated stimuli with different changes in specific dimensions
   2. For example: visual aftereffects to understand how orientation tuning is represented (by changing in small amounts orientation tuning)
2. Advantages of fMRI-Adaptation
   1. Shows more temporal resolution in EEG/etc
   2. Gives you knowledge about how the representation is stored
3. Disadvantages
   1. Requires that neurons are actually sensitive to repetition suppression, a null result does not indicate that no information is carried in that region. (also an MVPA problem)

Comparing fMRI-A and MVPA:

Neuroimage. 2010 Jan 15; 49(2): 1632–1640.

**A comparison of fMRI adaptation and multivariate pattern classification analysis in visual cortex** [Panagiotis Sapountzis](http://www.ncbi.nlm.nih.gov/pubmed/?term=Sapountzis%20P%5Bauth%5D),a [Denis Schluppeck](http://www.ncbi.nlm.nih.gov/pubmed/?term=Schluppeck%20D%5Bauth%5D),a [Richard Bowtell](http://www.ncbi.nlm.nih.gov/pubmed/?term=Bowtell%20R%5Bauth%5D),b and [Jonathan W. Peirce](http://www.ncbi.nlm.nih.gov/pubmed/?term=Peirce%20JW%5Bauth%5D)a,[low asterisk]

Spatial resolution is a fundamental limitation in fMRI, getting sub-voxel “selectivity” of neurons within a voxel requires using adaptation or MVPA. There is a debate remaining about what adaptation represents, but it’s clear that it works for a large number of stimuli.

For orientation tuning MVPA is more robust, less dependent on specific experimental parameters (e.g. stimulus presentation time). Clustering is important for MVPA, while adaptation parameters are crucial for fMRI-a.

The Effect of Attention on Repetition Suppression and Multivoxel Pattern Similarity

Katherine S. Moore1, Do-Joon Yi2, and Marvin Chun3

Both MVPA and fMRI-A depend crucially on attention, but only MVPA could discern an unattended stimulus. fMRI-A depends directly on attention for functionality (in this study).

Neural responses to visual scenes reveals inconsistencies between fMRI adaptation and multivoxel pattern analysis

[Russell A. Epstein](http://www.sciencedirect.com/science/article/pii/S0028393211004611), ,

[Lindsay K. Morgan](http://www.sciencedirect.com/science/article/pii/S0028393211004611)

Cortical surface-based searchlight decoding

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Local voxel patterns of fMRI signals contain specific information about cognitive processes ranging from basic

sensory processing to high level decision making. These patterns can be detected using multivariate pattern

classification, and localization of these patterns can be achieved with searchlight methods in which the

information content of spherical sub-volumes of the fMRI signal is assessed. The only assumption made by

this approach is that the patterns are spatially local. We present a cortical surface-based searchlight approach

to pattern localization. Voxels are grouped according to distance along the cortical surface—the intrinsic

metric of cortical anatomy—rather than Euclidean distance as in volumetric searchlights. Using a paradigm in

which the category of visually presented objects is decoded, we compare the surface-based method to a

standard volumetric searchlight technique. Group analyses of accuracy maps produced by both methods

show similar distributions of informative regions. The surface-based method achieves a finer spatial

specificity with comparable peak values of significance, while the volumetric method appears to be more

sensitive to small informative regions and might also capture information not located directly within the

gray matter. Furthermore, our findings show that a surface centered in the middle of the gray matter

contains more information than to the white–gray boundary or the pial surface.

# What do differences between multi-voxel and univariate analysis mean? How subject-, voxel-, and trial-level variance impact fMRI analysis

* [Tyler Davis](http://www.sciencedirect.com/science/article/pii/S1053811914003061)[a](http://www.sciencedirect.com/science/article/pii/S1053811914003061#af0005), , [1](http://www.sciencedirect.com/science/article/pii/S1053811914003061#fn0005), ,
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Multi-voxel pattern analysis (MVPA) has led to major changes in how fMRI data are analyzed and interpreted. Many studies now report both MVPA results and results from standard univariate voxel-wise analysis, often with the goal of drawing different conclusions from each. Because MVPA results can be sensitive to latent multidimensional representations and processes whereas univariate voxel-wise analysis cannot, one conclusion that is often drawn when MVPA and univariate results differ is that the activation patterns underlying MVPA results contain a multidimensional code. In the current study, we conducted simulations to formally test this assumption. Our findings reveal that MVPA tests are sensitive to the magnitude of voxel-level variability in the effect of a condition within subjects, even when the same linear relationship is coded in all voxels. We also find that MVPA is insensitive to subject-level variability in mean activation across an ROI, which is the primary variance component of interest in many standard univariate tests. Together, these results illustrate that differences between MVPA and univariate tests do not afford conclusions about the nature or dimensionality of the neural code. Instead, targeted tests of the informational content and/or dimensionality of activation patterns are critical for drawing strong conclusions about the representational codes that are indicated by significant MVPA results.

In short: MVPA gives us access to certain representations that can’t be accessed in univariate. It doesn’t necessarily give us direct access to a ‘multi-dimensional code’. Modeling specific neural coding schemes is the real answer: and MVPA gives us access to the data necessary for that modeling.