**Paper**: Poldrack 2011 - Inferring mental states from neuroimaging data: from RI to Large-scale decoding.

Summary.

Bayes’ rule estimates how likely the mental process M is, given the activity pattern A. P(M|A) = P(A|M)P(M) / P(A). Where NeuroImaging data = P(A|M).

The reverse inference is a strategy to generate novel hypotheses in Neuroscience and an example of “abductive inference”. The latter is a method used in scientific thinking in which the researcher makes probable conclusions from the information he already possesses (prior). It is the opposite of "deductive inference", in which what is inferred is necessarily true if the prior is true. In particular, the demonstration of a *significant decoding* of a regionvia fMRI data, **does not imply** that the region **is necessary** for the mental function being decoded.

Computational models and statistical information extracted from large online databases (e.g. BrainMap) are used to mirror the supposed brain decoding strategies underlying psychological functions.

However, as mentioned above, the accurate decoding of mental states engaged in a particular task is limited by the current knowledge of these processes.

Moreover, a *large scale classification* of mental processes (i.e. across multiple possible mental states being decoded and neural systems being involved) is mainly theoretical due to insufficiently detailed fMRI datasets (tasks and processes involved in each data set are not sufficiently accurate to perform valid reverse inference testing).

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**Key words and definition:**

1. **RI = reverse inference.** Def. From brain’s activation pattern A, infer the likelihood of its engagement in a particular mental function M. (mental = psychological).
2. **Formula**: Bayes’s rule. P(M|A) = P(A|M)P(M) / P(A). Where **NeuroIm. data = P(A|M)**

**Main ideas in Physics and Philosophy**:

1. Use Bayes’ rule to estimate how likely the mental process M is, given the activity pattern A.  
   Question: How predictive an *activation map A* is for a particular mental process M?
2. **RI is a strategy** to generate novel hypotheses in neuroscience **if and only if** it is based on real data.  
     
   (e.g. “meta-analytic maps” - automatically extracted *activation coordinates* from fMRI data to test RI. See BrainMap database. Note: it is biased.)
3. **RI as an e.g. of “abductive inference”** that is a means of scientific reasoning.   
   *Def*. **abductive inference** means “making a *probable conclusion* (=“reasoning for the best explanation”) from the info that is already known (=evident major premise = prior)”.
4. Neuroimaging data are **inherently correlational**.   
   Hence, the demonstration of a significant decoding of a region **does not imply** that the region **is necessary** for the mental function being decoded.
5. **Model-based approach as a decoding strategy:**

Aim: decoding of A via computational models characterizing *supposed* mental processes underlying psychological functions, and via statistical information extracted from large online databases.

**Main limitations on the decoding strategies**:

1. The ability to classify mental processes on *large scale* (i.e. across a large number of possible mental states being decoded, and across relevant neural systems being involved) is largely theoretical due to the **lack of detailed annotation of neuroimaging datasets** (description of both tasks and processes associated with each fMRI data set).
2. The ability to accurately decode mental states engaged in a particular task is fundamentally **limited by the accuracy of the ontology describing** those mental entities.   
     
   e.g. For *fine-grained decoding* (“is the subject viewing a cat or a horse?”), the organization of those mental states is relatively well defined.  
   Whereas,for *higher-level mental functions* (“is the subject engaging working memory?”), there is less agreement on the existence of this function.

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Ontology =study of the existence of smth