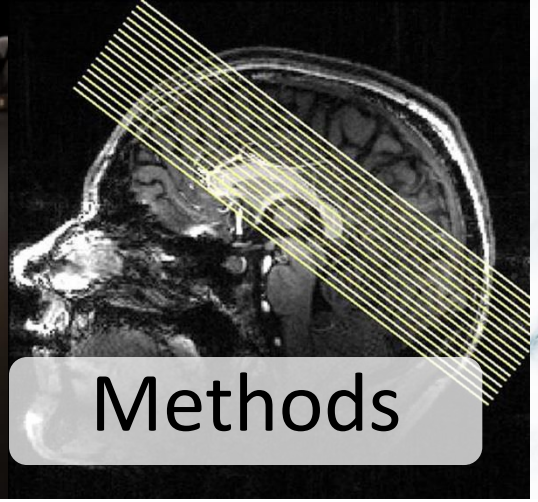
NEUROCOG'16

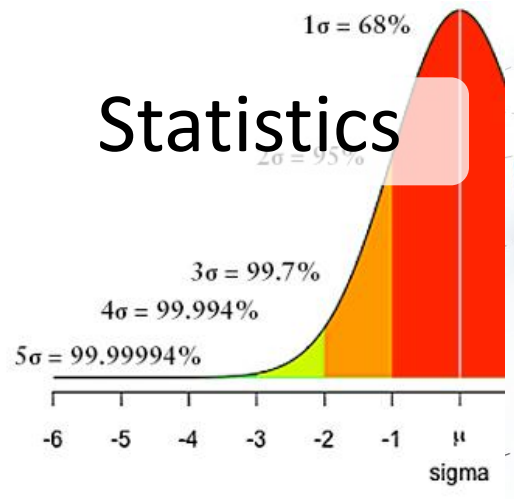
How methods bias the mind of cognitive neuroscientists

Coordinates-based meta-analyses (CBMA) of neuroimaging studies: A critical overview

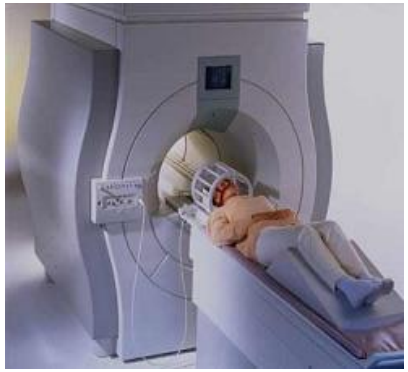
by Henryk Bukowski
Univ. of Vienna, Austria



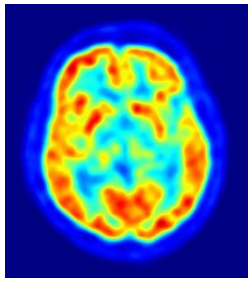
Problem 1: overwhelming number of studies
Problem 2: fMRI is prone to false positives
Problem 3: high inter-studies variability
Solution: Look at consistencies across studies



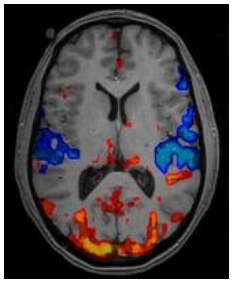
PET & fMRI



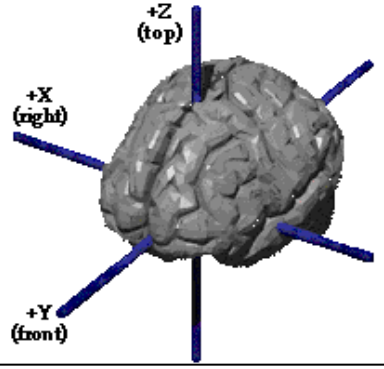
Positron Emission Tomography (PET)



Functional Magnetic Resonance Imaging (fMRI)



Coordinates-based



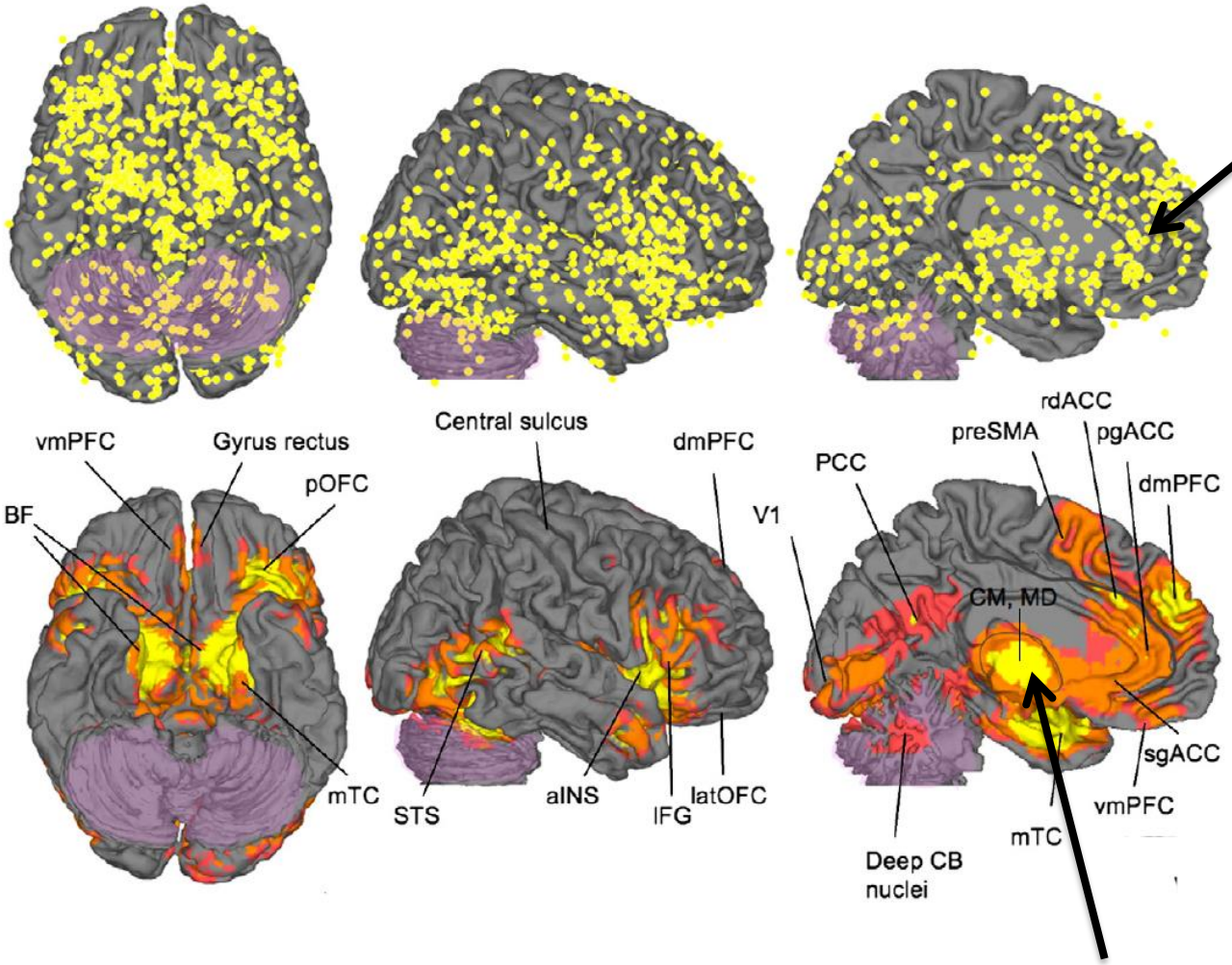
	fMRI			
	x	y	z	*Z* score
L Precent G (4/6)	−46	−8	32	7.18
R Precent G (6)	48	−3	24	7.31
R Sup Temp S (22/21)	55	−23	5	5.65
R Med Sup Fr G (6)	4	11	55	5.84

Meta-analysis

Table 1
Overview of the 87 studies included in the meta-analysis on action observation and imitation.

Publication	Subjects	Mode	Experiment (rep. foci)	Effector (o/no)	Instruction	Contrast	Stimulus
Adamovich et al., 2009	13	fMRI	OBS (24)	Hand (o)	Observe to imitate	Task>rest	Hand manipulating objects
			IMI (14)	Hand (o)	Imitate as observed	Task>rest	Hand manipulating objects
Agnew and Wise, 2008	20	fMRI	OBS (5)	Right hand (no)	Passively observe	OBS motion>OBS static	Hand static or moving
			OBS (11)	Right hand (no)	Passively observe	OBS motion>EXE motion	Hand static or moving
Aziz-Zadeh et al., 2006a	12	fMRI	IMI (25)	Right hand (o)	Imitate as observed	Task>rest	Finger movement
			IMI (30)	Left hand (o)	Imitate as observed	Task>rest	Finger movement
Aziz-Zadeh et al., 2006b	12	fMRI	OBS (9)	Hand/foot/face (o)	Passively observe	Task>rest	Combination of lower three

Concretely…



Peak activations reported in studies

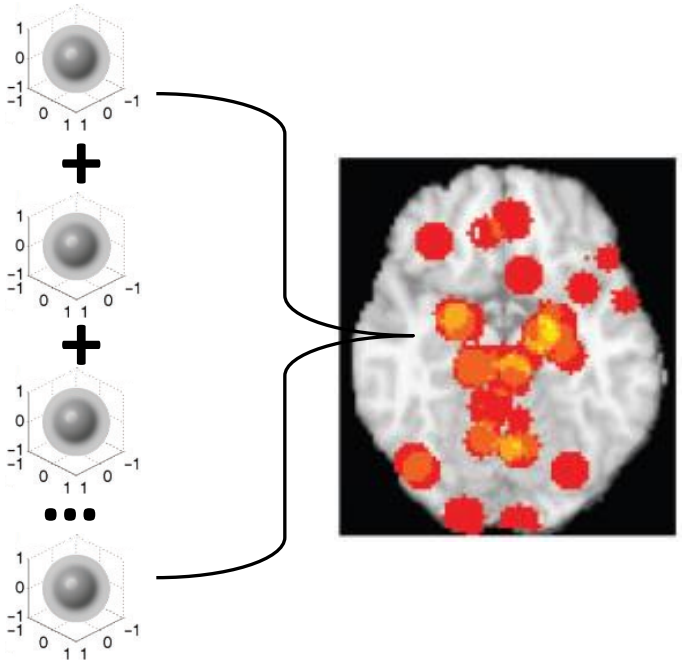
Statistical processing

Statistically significant : "Very low likelihood that peaks overlap across studies in these brain areas because of randomness"

The stats in a glimpse (1/2)

Each **voxel** of the brain
receives a value

Kernels adding up…



?

How to tell
if it is significant?

The stats in a glimpse (2/2)

?

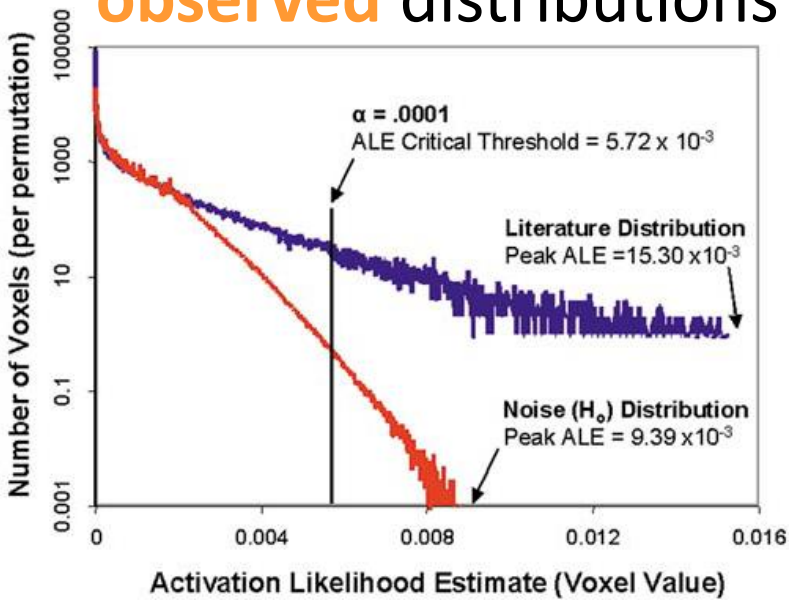
How to tell
if it is significant?

H_0 What is the
null hypothesis?

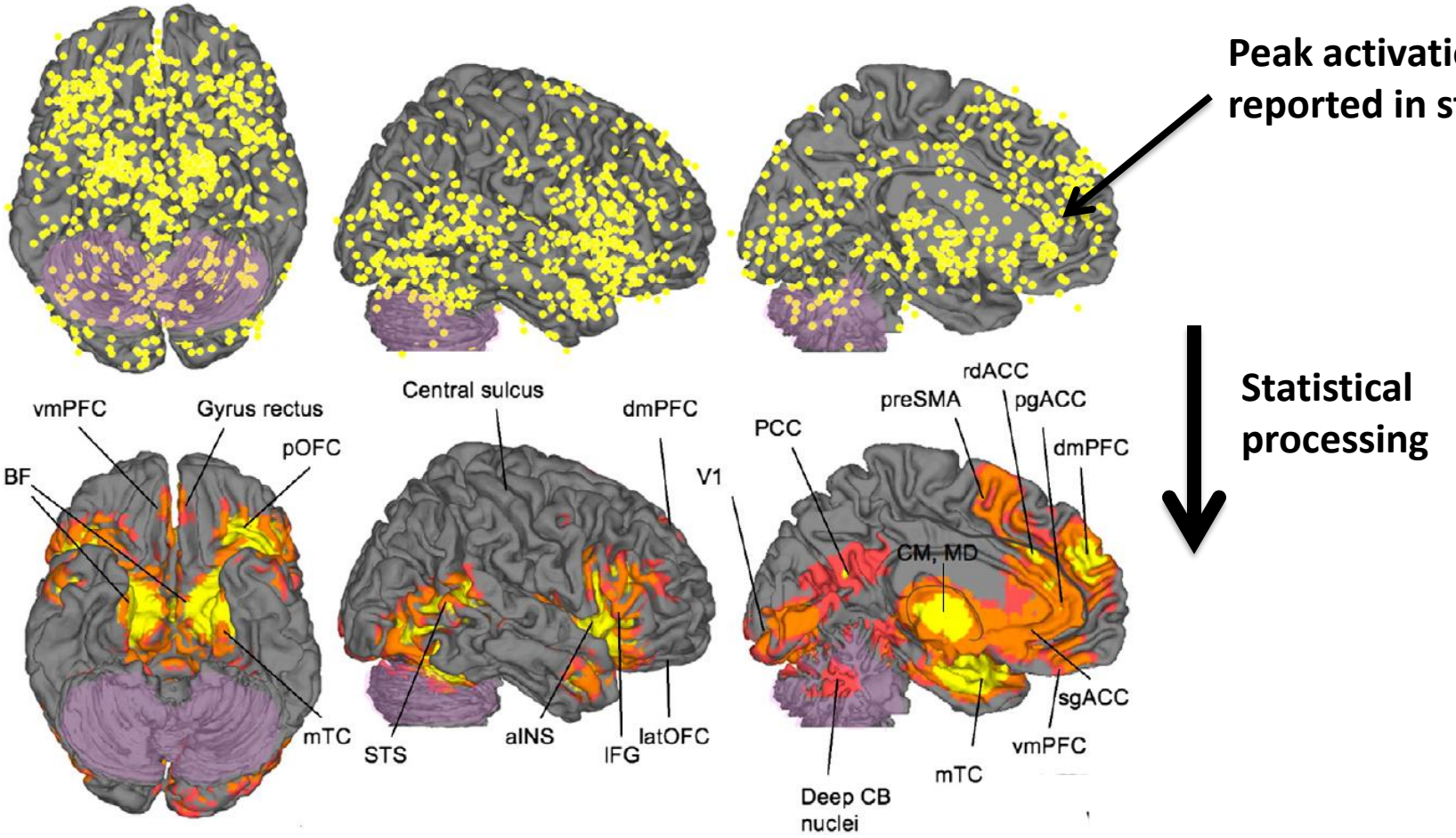
A **random** distribution
of the peaks within
the brain

simulation repeated
thousands of times
(Monte Carlo)

Compare the **random** and
observed distributions



Choose a stat **threshold** (α)
(corrected for multiple comparisons)


Peak activations reported in studies
Statistical processing
vmPFC
Gyrus rectus
pOFC
BF
mTC
Central sulcus
dmPFC
STS
aINS
lFG
latOFC
rdACC
preSMA
pgACC
PCC
dmPFC
V1
CM, MD
sgACC
vmPFC
mTC
Deep CB nuclei

The 3 most popular softwares

Criteria	GingerALE	SDM	MKDA
User friendliness	+++	+	-
Task/topic comparison	V	V	V
Multi-comparison thresholding	V	V	V
Clustering	V	V	V
Weight by sample size	V	V	V
Weight same vs. different study	(V)	V	V

Radua & Mataix-Cols, 2012; Wager, Lindquist et al., 2009; Turkeltaub, Eickhoff et al., 2012

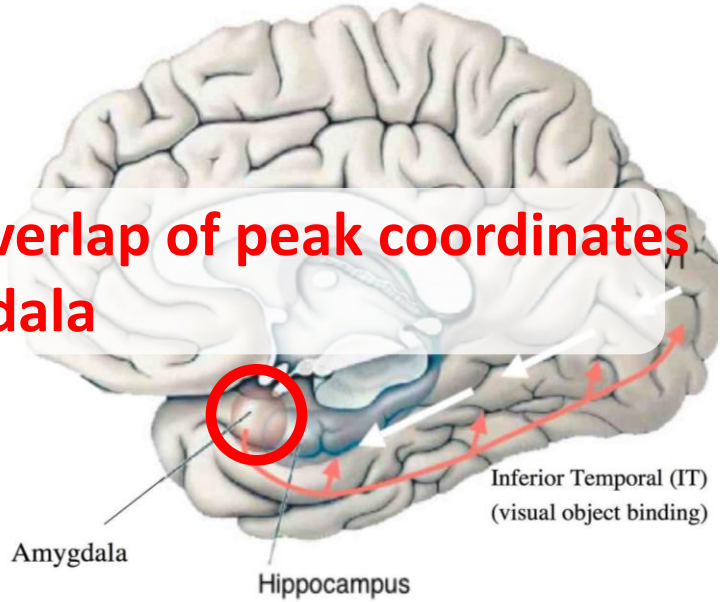
CBMA depends on one big assumption

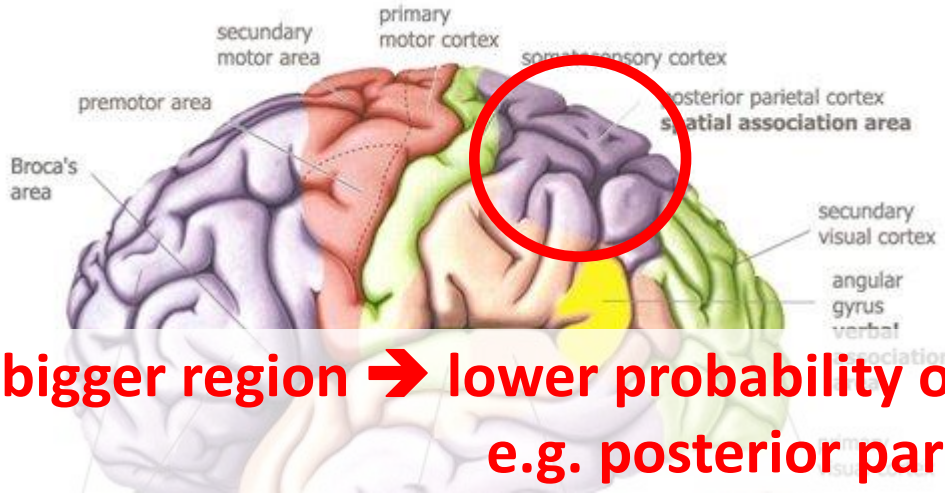
Every grey matter voxel has the same likelihood of being reported

At least 4 reasons to think it isn't the case

1: Size matters !

smaller region ➔ higher probability of overlap of peak coordinates
e.g. amygdala





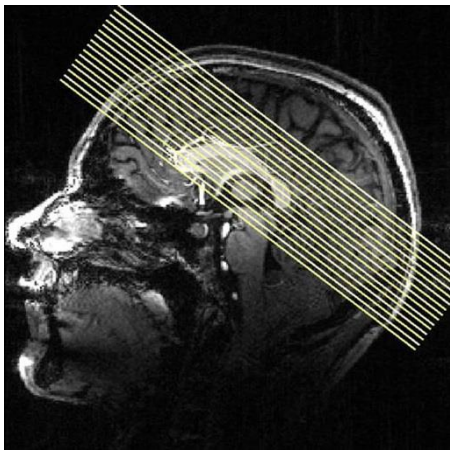
bigger region ➔ lower probability of overlap of peak coordinates
e.g. posterior parietal cortex

2: Limited scanned volume

Not all brain regions are consistently scanned

Brain extremities are often **outside the brain scan** span because of the acquisition time – number of slices tradeoff

➔ **lower probability of overlap of peak coordinates**
e.g. posterior parietal cortex



3: Region Of Interest

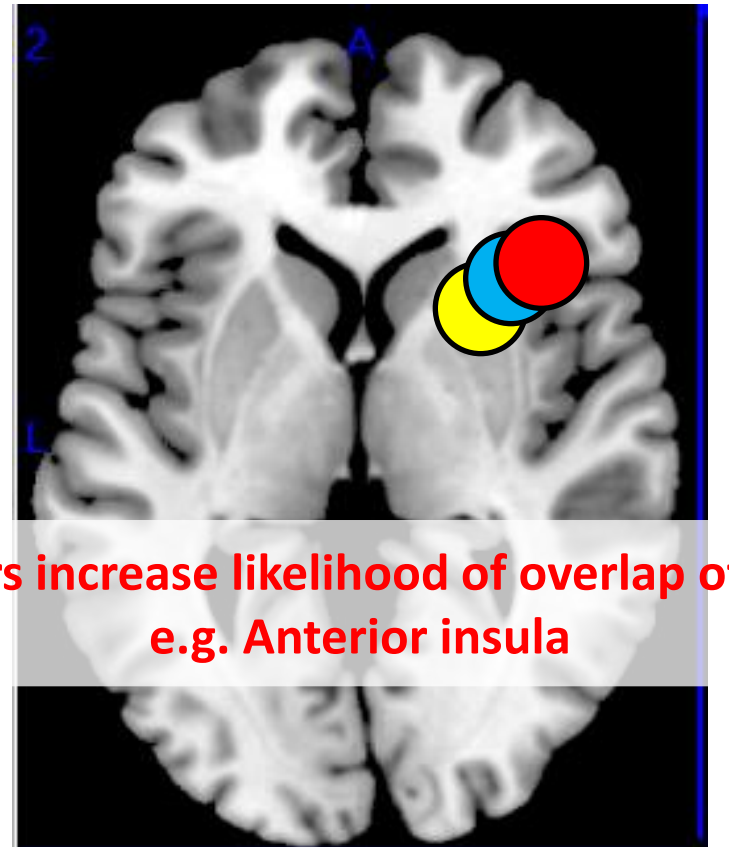
Not all brain regions are consistently analyzed

Region Of Interest (ROI) vs. Whole brain results

➔Regions from previous studies
are more likely to become reported again !

4: Smoothing

Boundaries between regions are smoothed (again)



Frontal cortex
Insular cortex
Striatum

➔ **Active neighbors increase likelihood of overlap of peak coordinates**
e.g. Anterior insula

CBMA depends on one big assumption

Every grey matter voxel has the same likelihood of being reported ?

At least 4 reasons to think it isn't the case

1. Size matters
2. Limited scanned volume
3. Region of Interest analysis
4. Smoothing

The cost of consistency

It (only) capture consistencies

What's wrong with that?

➔Consistent but low activation are captured
➔Inconsistent but high activation are lost

➔➔ **Unspecific** (active for many variants of a psychological process) **with low tuning** (i.e., smaller relative activation) are more likely to be captured !

CBMA shapes our brain towards consistency

By focusing on consistency, we might loose the specificity & the particularity of the psychological process.

The case of pain & empathy for pain:

→ Anterior insula and mid cingulate cortex are most consistently reported and thus were considered as “biological markers”, but they are actually very **unspecific** to pain and empathy for pain.
→ Each particular painful experience will recruit other brain areas potentially characterizing the particularity of that painful experience.
→ **CBMA leads us to ignore these less consistent regions**.

Summary

- Coordinate-based meta-analyses (CBMA) summarize neuroimaging results by looking at consistent activations across studies

- Reliability of the results is dependent upon the assumption that every grey matter voxel has the same likelihood of being reported (but it hasn’t !)

- CBMA shapes our brain in looking only at consistencies with the risk of ignoring the regions that actually characterize the investigated psychological process

Thank you for your attention