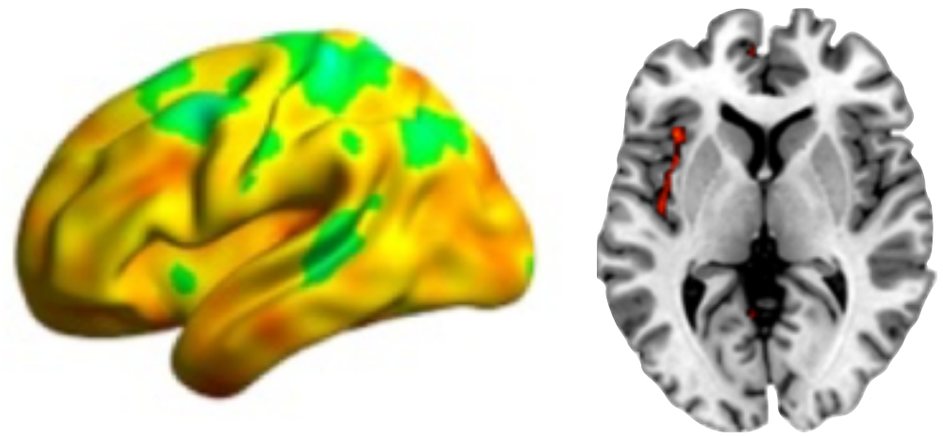
2-Sample T-test & Pair-T test

[including some tips !?]



Kun-Hsien Chou, Ph.D (周坤賢)

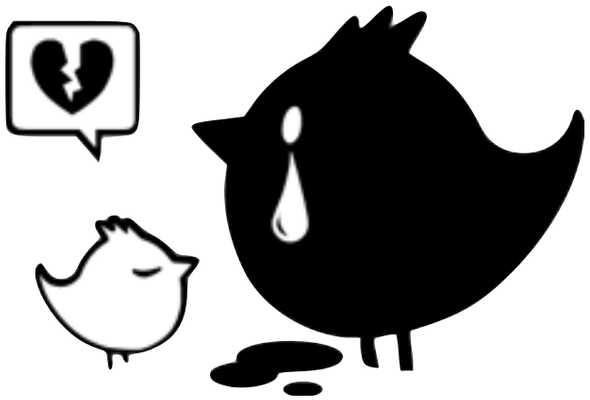
2017.07.19

Assistant professor I Institute of neuroscience I National Yang Ming University

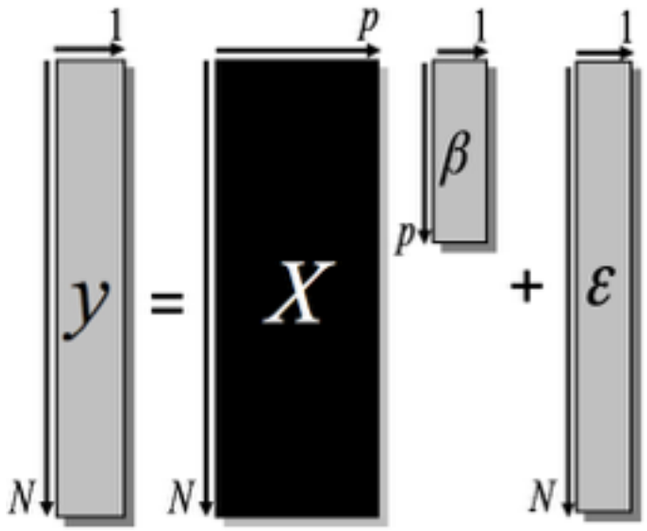
Assistant research fellow I Brain Research Center I National Yang Ming University

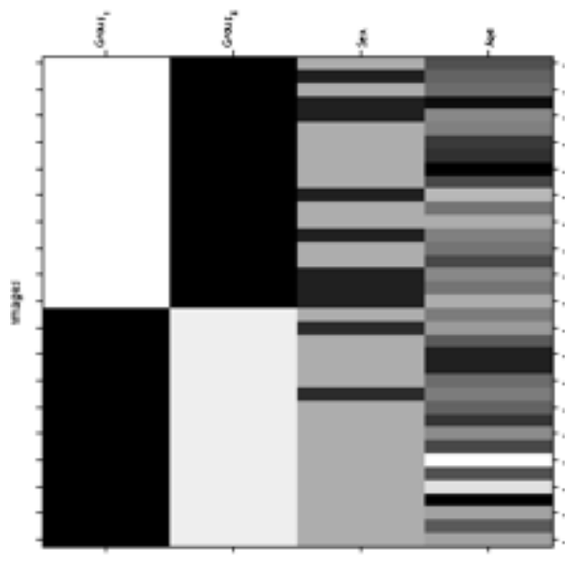
In this short 90 mins course

Real world examples

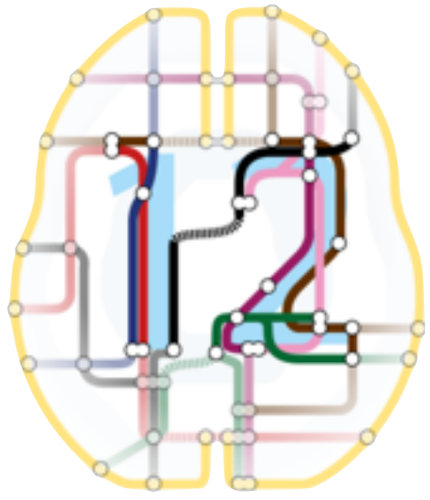


Mathematical formula



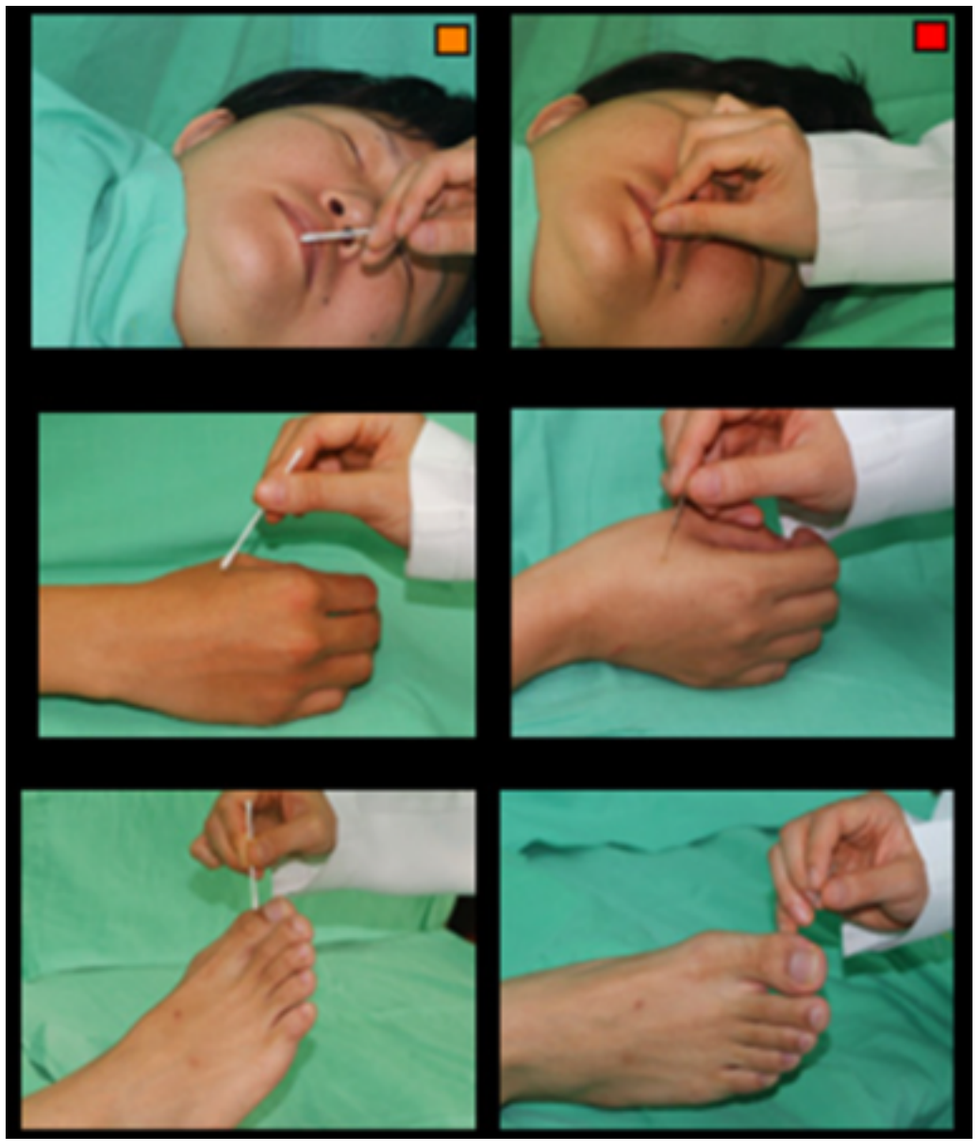


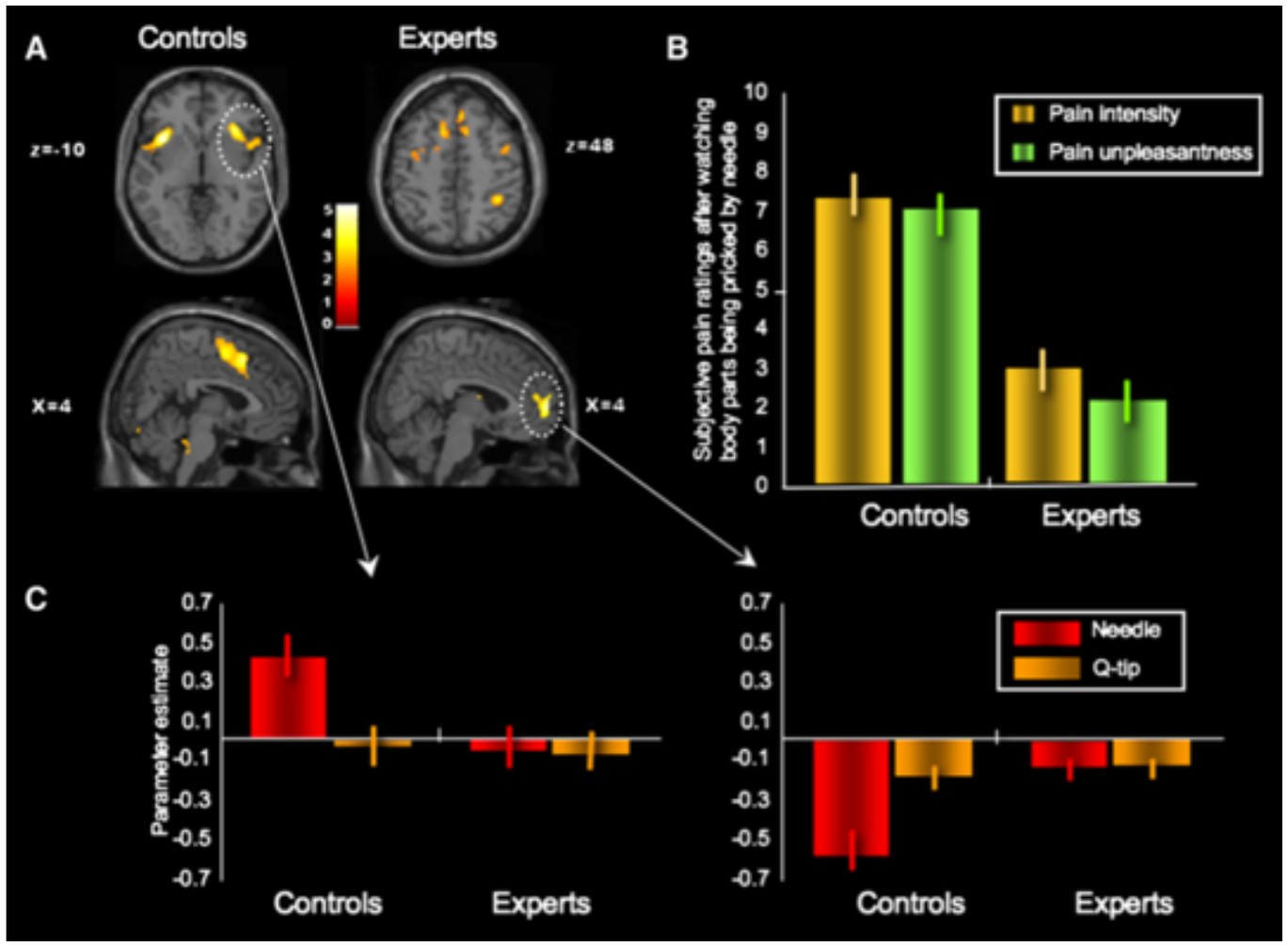
Answer with SPM



My first task-fMRI study. Almost ten years ago !

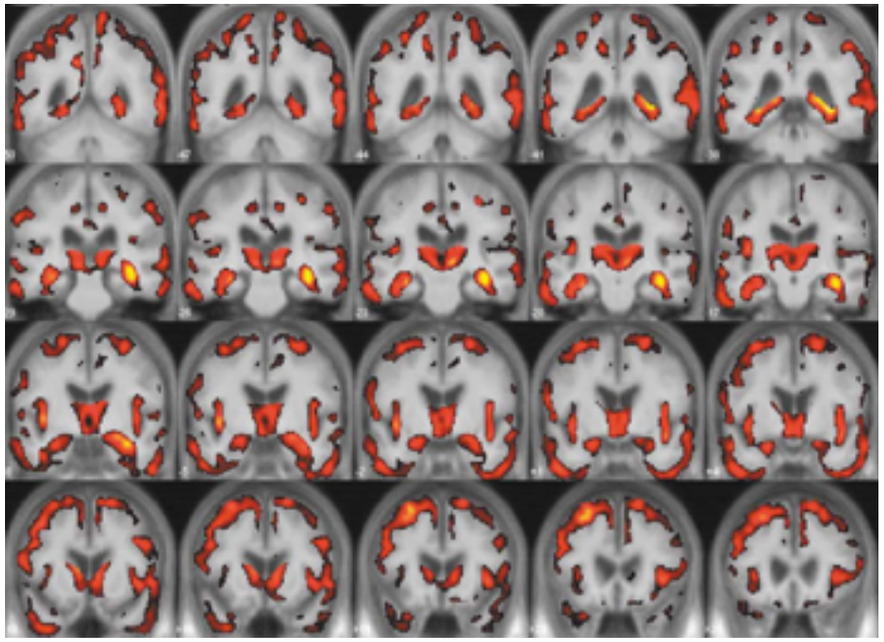
Expertise Modulates the Perception of Pain in Others



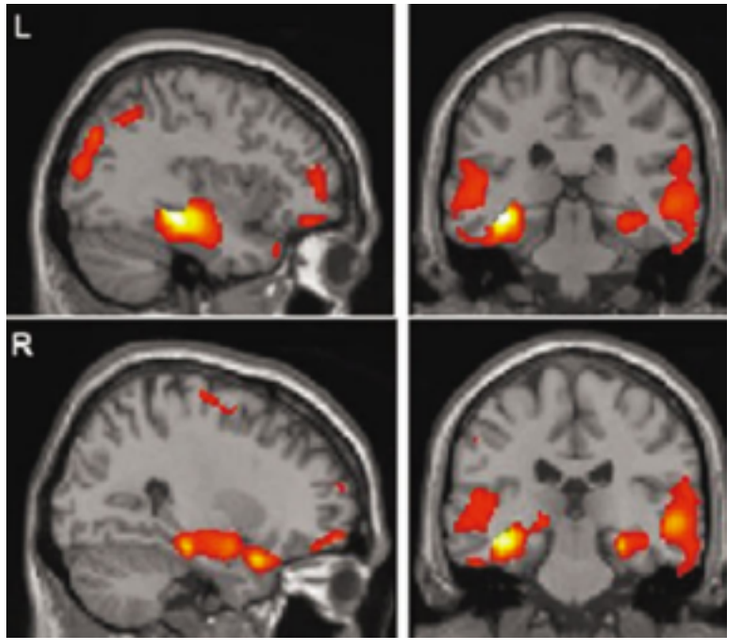


Experts using different stagey to perform their job !!

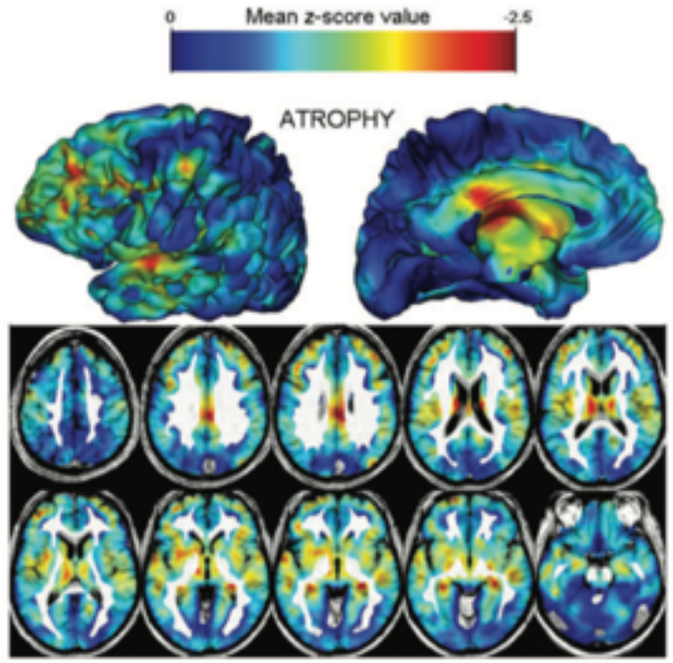
Brain morphometric changes in patient with Alzheimer disease



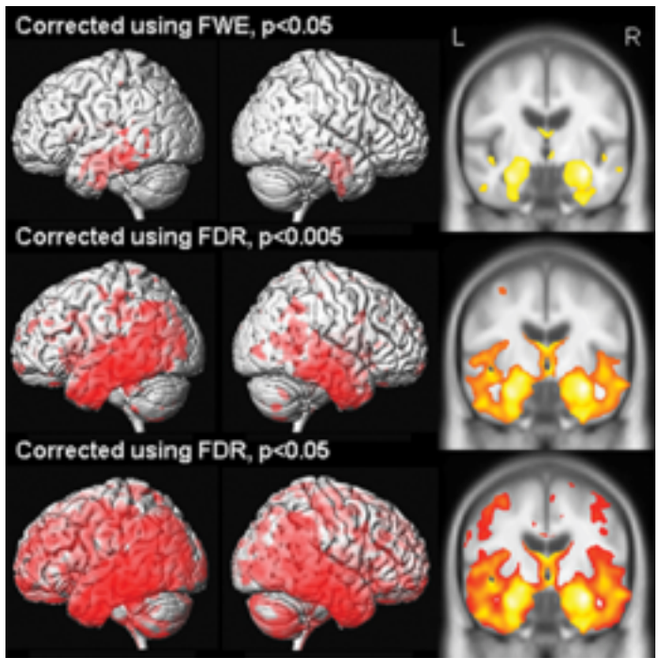
Karas et al. Neuroimage. 2003.



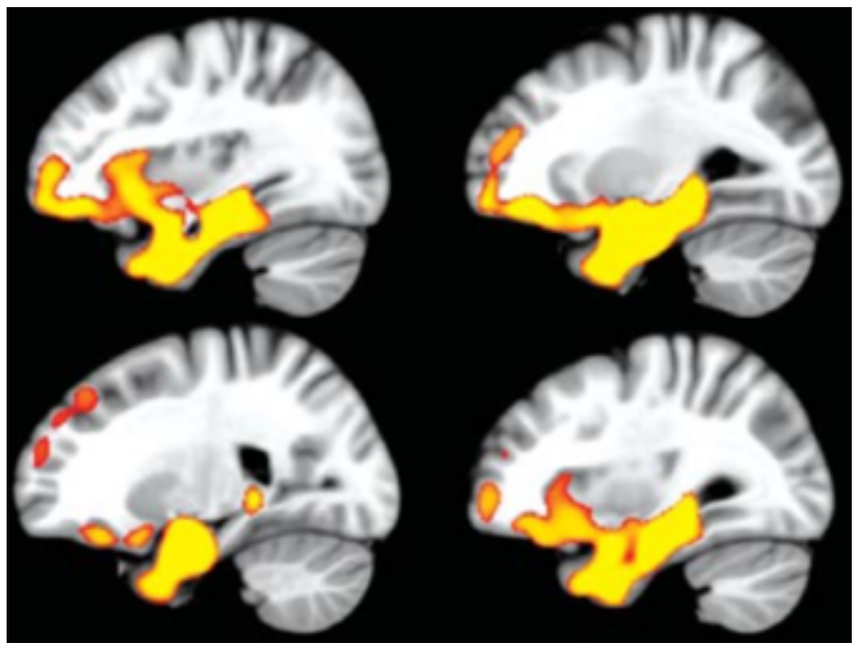
Testa et al. JMRI. 2004.



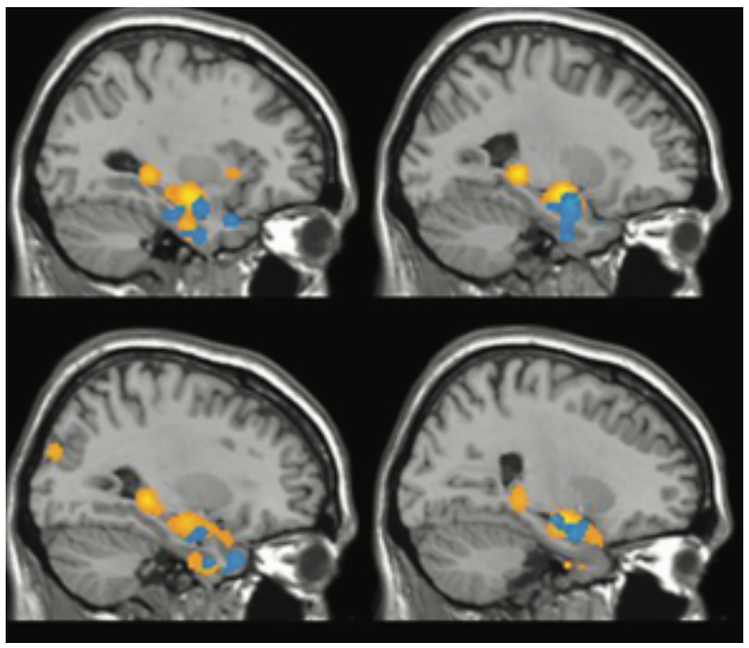
Chetelat et al. Brain. 2008.



Whitwell et al. Journal of neuroscience. 2009.

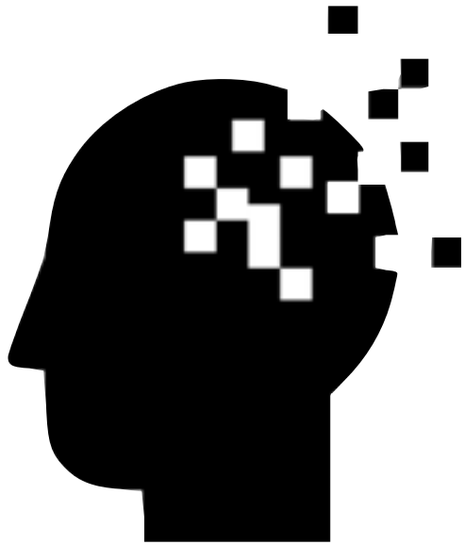


Wang et al. J. Alzheimers Dis. 2012.

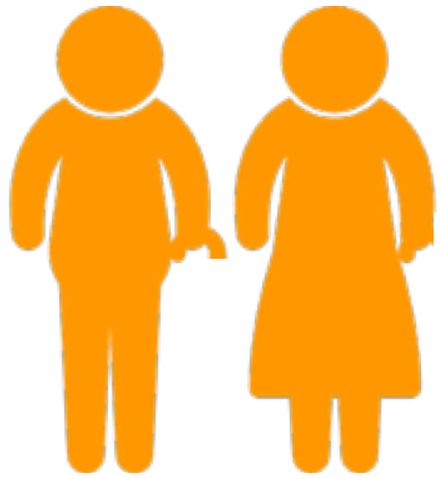


Chapleau et al. J. Alzheimers Dis. 2016.

Deconstructing the framework of scientific papers !



V.S.



control vs. experts

healthy controls vs. AD

[2-sample T test]

Recall your memory back !

fMRI data

First level modeling

Voxel-wised map

Group (2nd level) analysis

Group 1

Subject 1

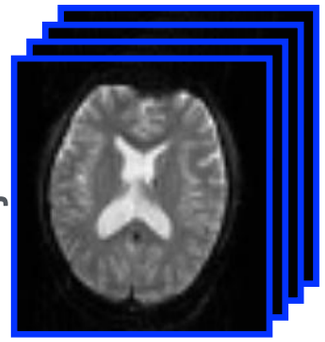
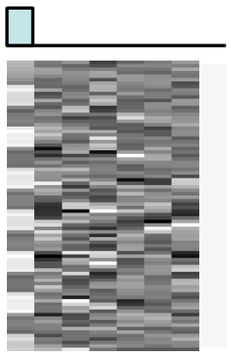
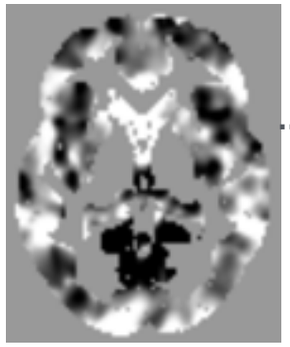


Image preprocessing





fMRI data

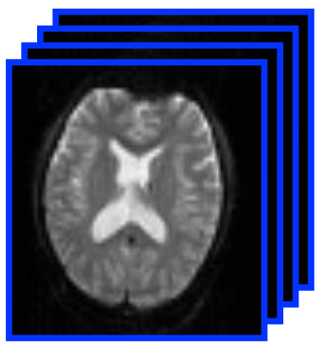
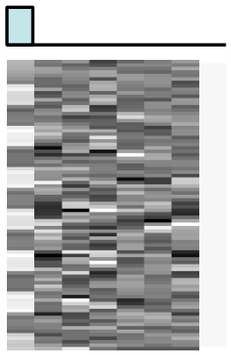
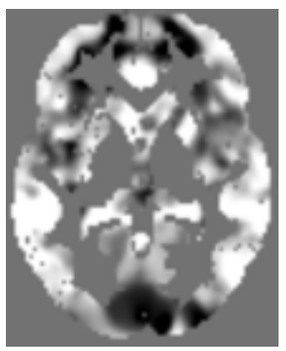


Image preprocessing





fMRI data

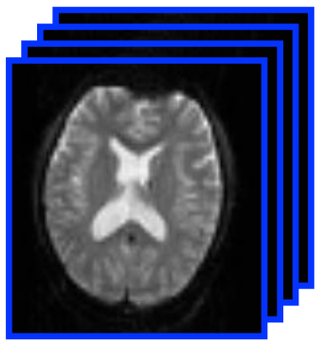
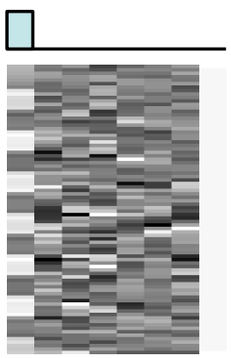
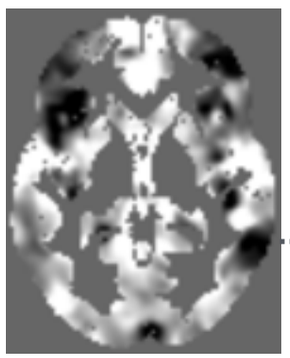


Image preprocessing





Group 2

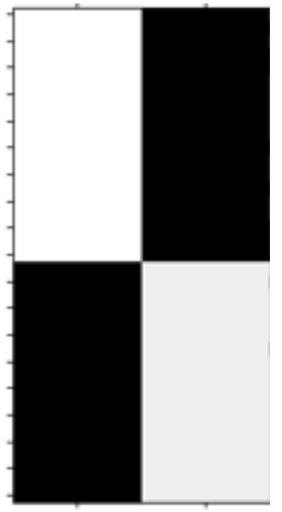
Subject N

first level modeling

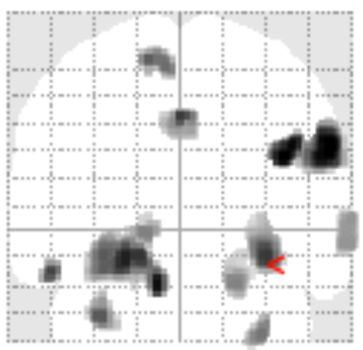
voxel-wised map

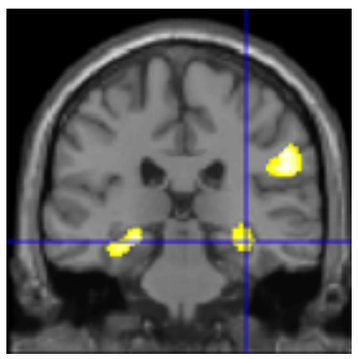
first level modeling

voxel-wised map

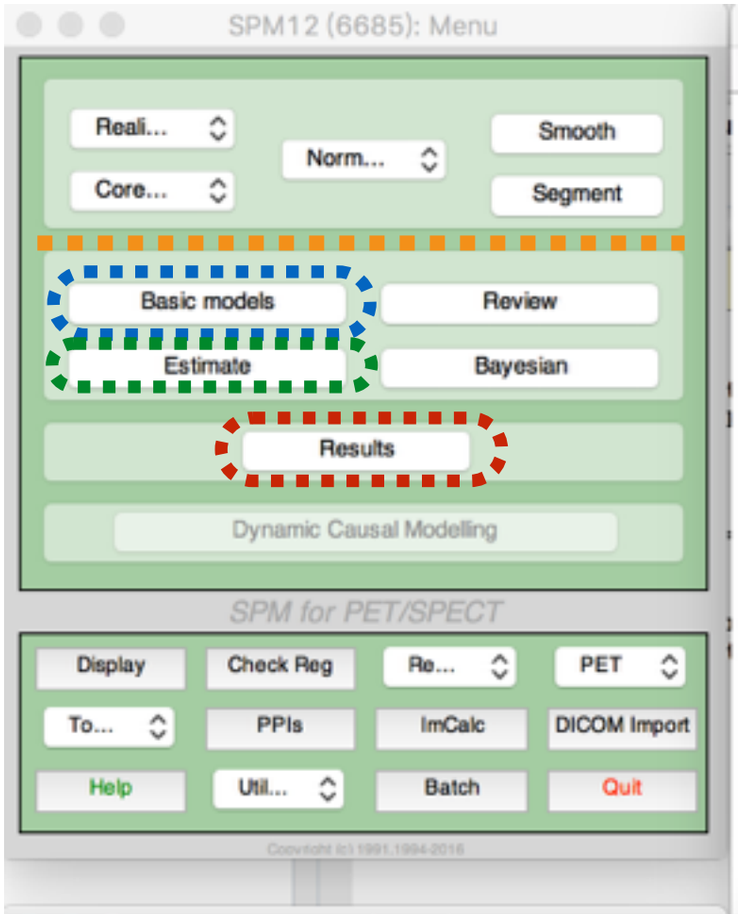


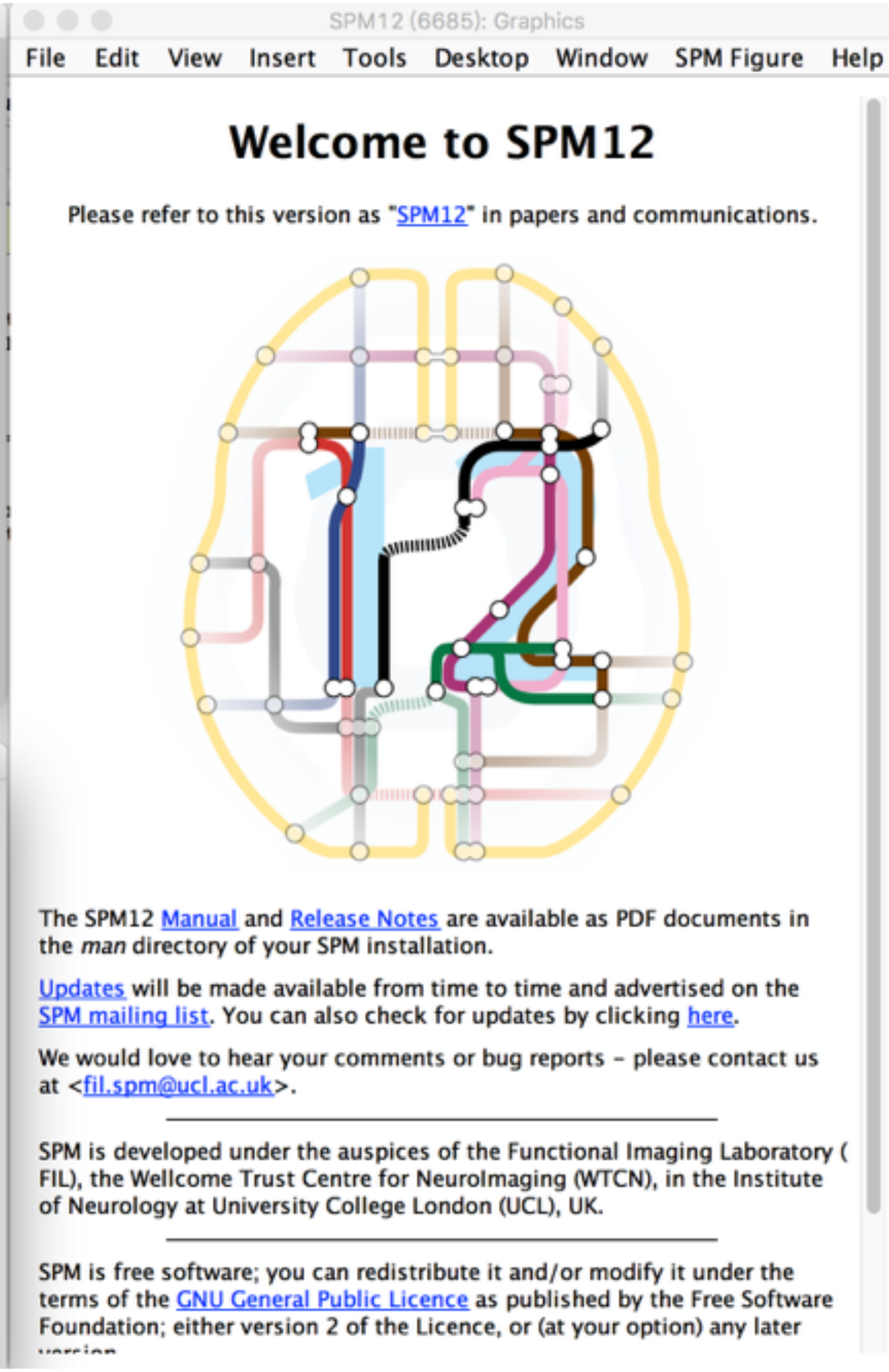
Group level (2nd) statistics





The Interface of Statistical Parametric Mapping



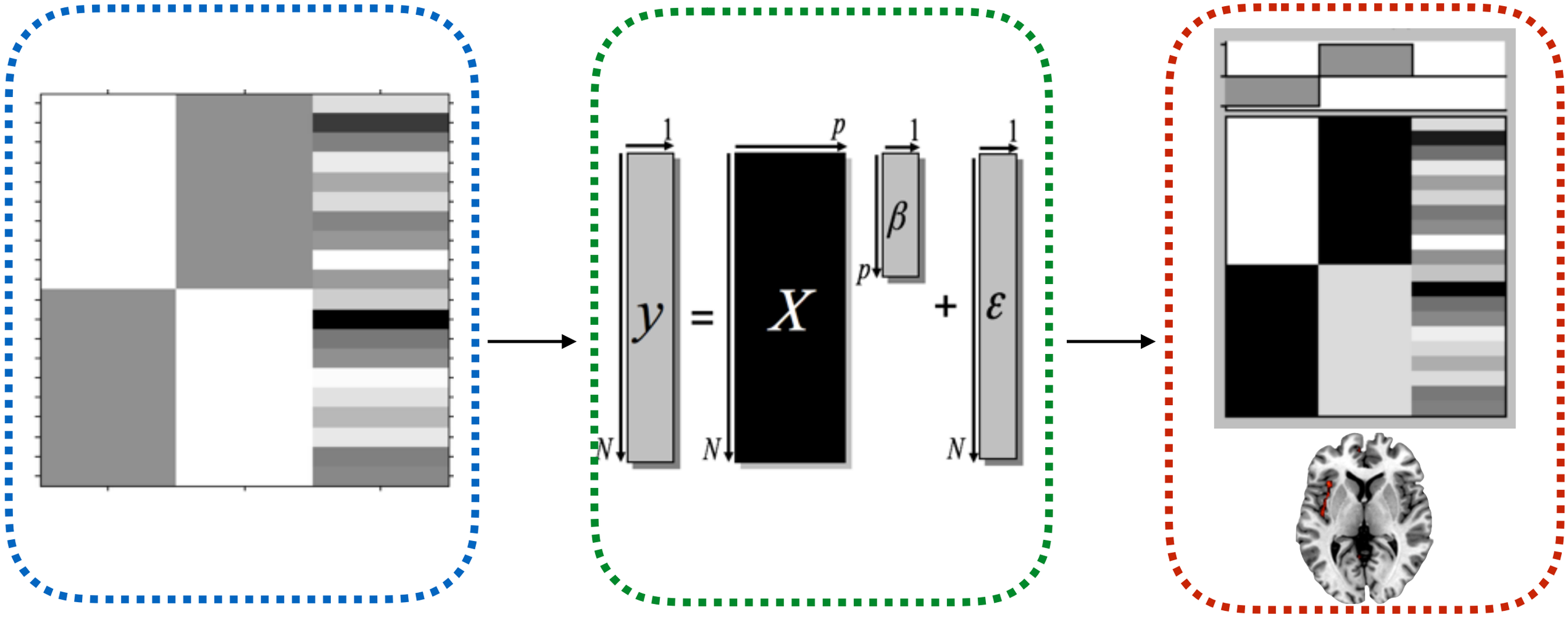


Model Construction

Model Estimation

Statistical Inference

The basic statistical pipeline of SPM



Model Construction

Model Estimation

Statistical Inference

General Linear Model - Modeling your scientific questions

Why? Make inferences about effects of interest

How?
- Decompose data into effects and error
- Form statistic using estimates of effects and error

$$Y = X \times \beta + E$$

Dependent Variable (What you are measuring)

Independent Variable (What you are manipulating)

Relative Contribution (These need to be estimated)

Error (The difference between the observed data and that which is predicted by the model)

Aim: To explain as much of the variance in Y by using X, and thus reducing E

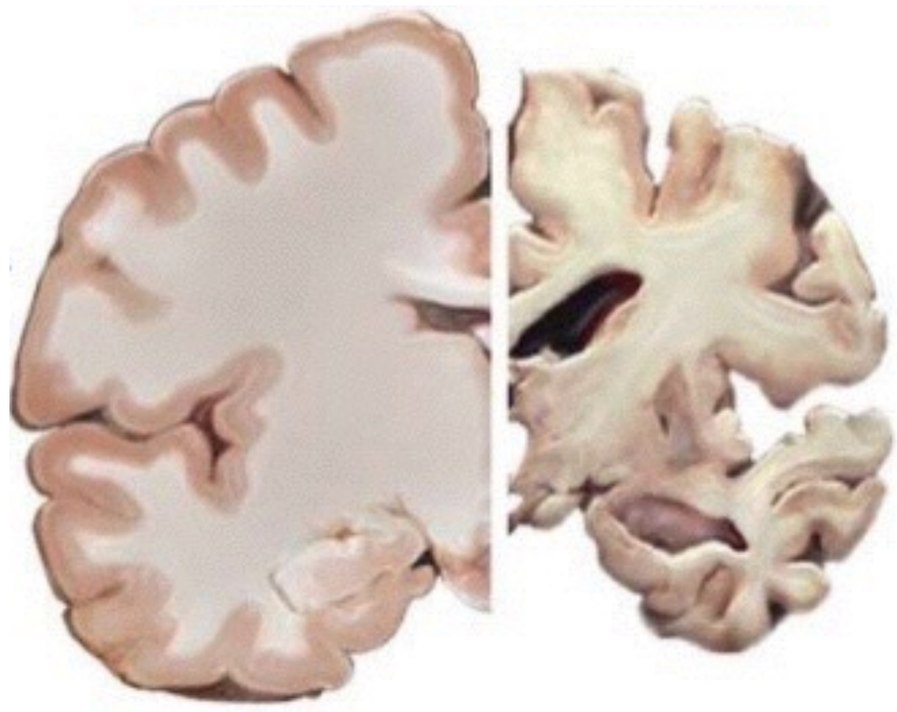
More than 1 EV ? $Y = X_1\beta_1 + X_2\beta_2 + \ldots X_n\,\beta_n \ldots + E$

Univariate analysis !!

Example 1:

Is there any gray matter volume difference between

healthy controls and patient with Alzheimer’s disease !?



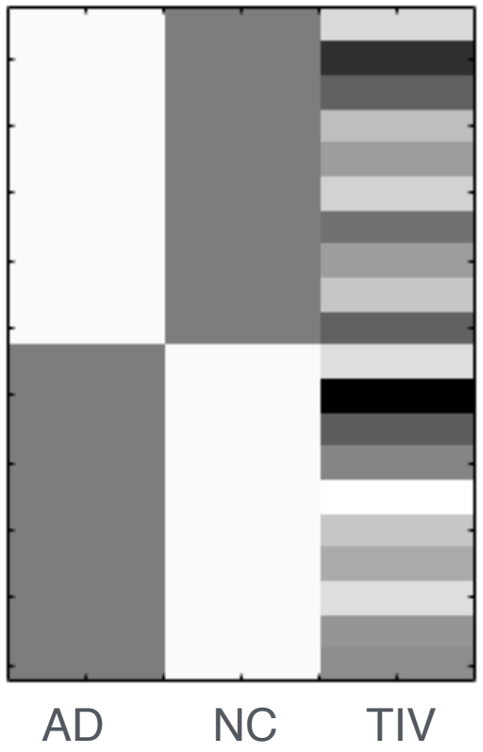
Gray matter volume atrophy in patients with Alzheimer's disease

"Is there significantly lower gray matter volume

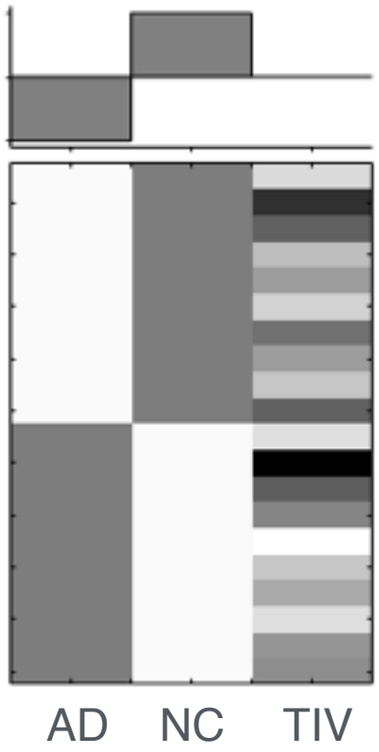
in the patients with Alzheimer disease than in the healthy controls

after adjusting total intracranial volume ?"

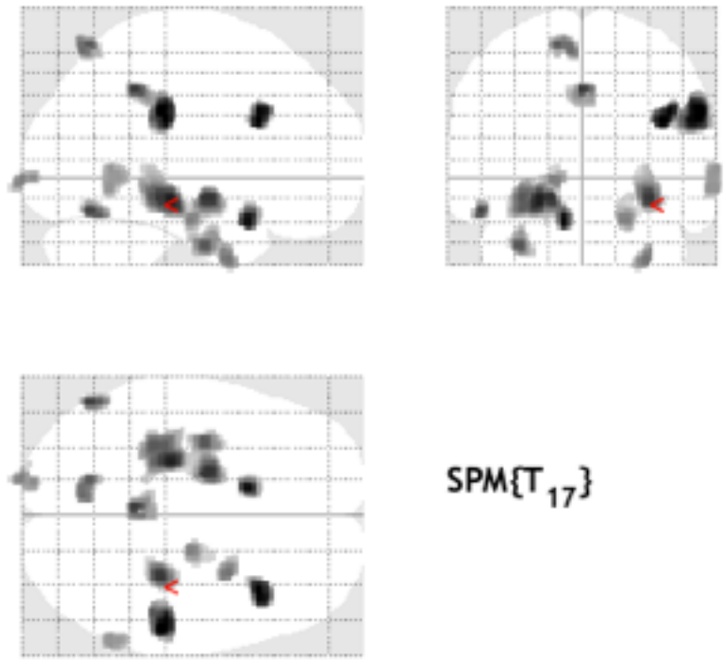
$$Y = \beta_1(AD) + \beta_2(NC) + \beta 3(TIV) + \varepsilon$$



Model construction



Statistical inference



Result visualization

Full factorial design (Model Construction)

Current Module: Factorial design specification

Help on: Factorial design specification	
Directory	/Users/PaulSmith/Analyze_Field/NTU_SPM_Statistical_Course_Demo/1_Two_Sample_T_Test/3_Two_Sample_T_Design
Design	
. Full factorial	
. . Factors	
. . . Factor	
. . . . Name	Group
. . . . Levels	2
. . . . Independence	Yes
. . . . Variance	Equal
. . . . Grand mean scaling	No
. . . . ANCOVA	No
. . Cells	
. . . Cell	
. . . . Levels	1
. . . . Scans	10 files
. . . Cell	
. . . . Levels	2
. . . . Scans	10 files
. . Generate contrasts	No
Covariates	
. Covariate	
. . Vector	20x1 double
. . Name	TIV
. . Interactions	None
. . Centering	Overall mean
Multiple covariates	
Masking	
. Threshold masking	
. . None	
. Implicit Mask	Yes
. Explicit Mask	/Users/PaulSmith/Analyze_Field/NTU_SPM_Statistical_Course_Demo/1_Two_Sample_T_Test/2_Covariates/Final_GM_Mask.nii,1
Global calculation	
. Omit	
Global normalisation	
. Overall grand mean scaling	
. . No	
. Normalisation	None

Directory:

The output directory of your statistical model

Design:

The statistical model you want to use (Full factorial)

[The definition of : Factors, Name, Level, Cell and Scans]

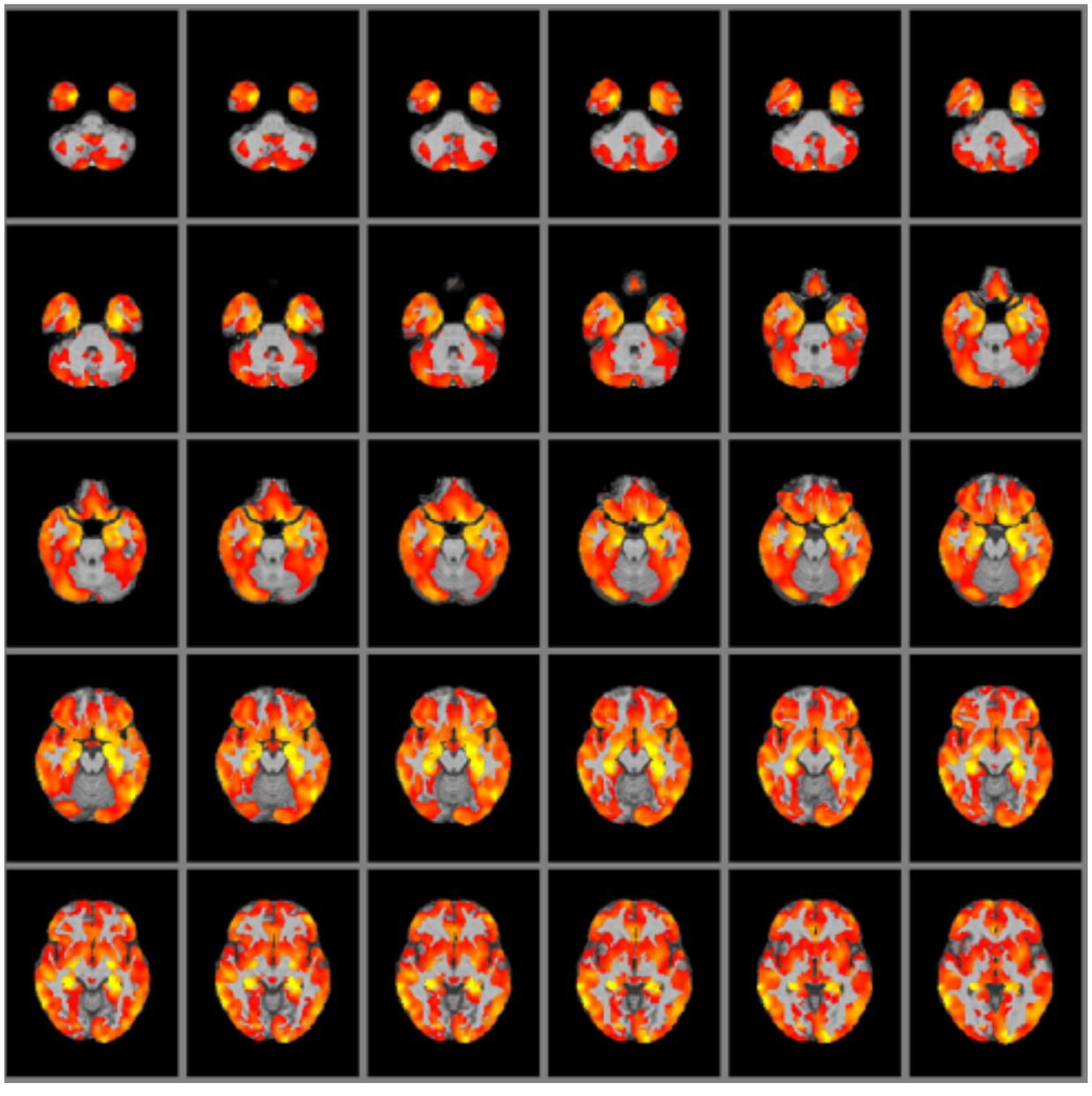
Covariates:

The effect you want to adjust (TIV)

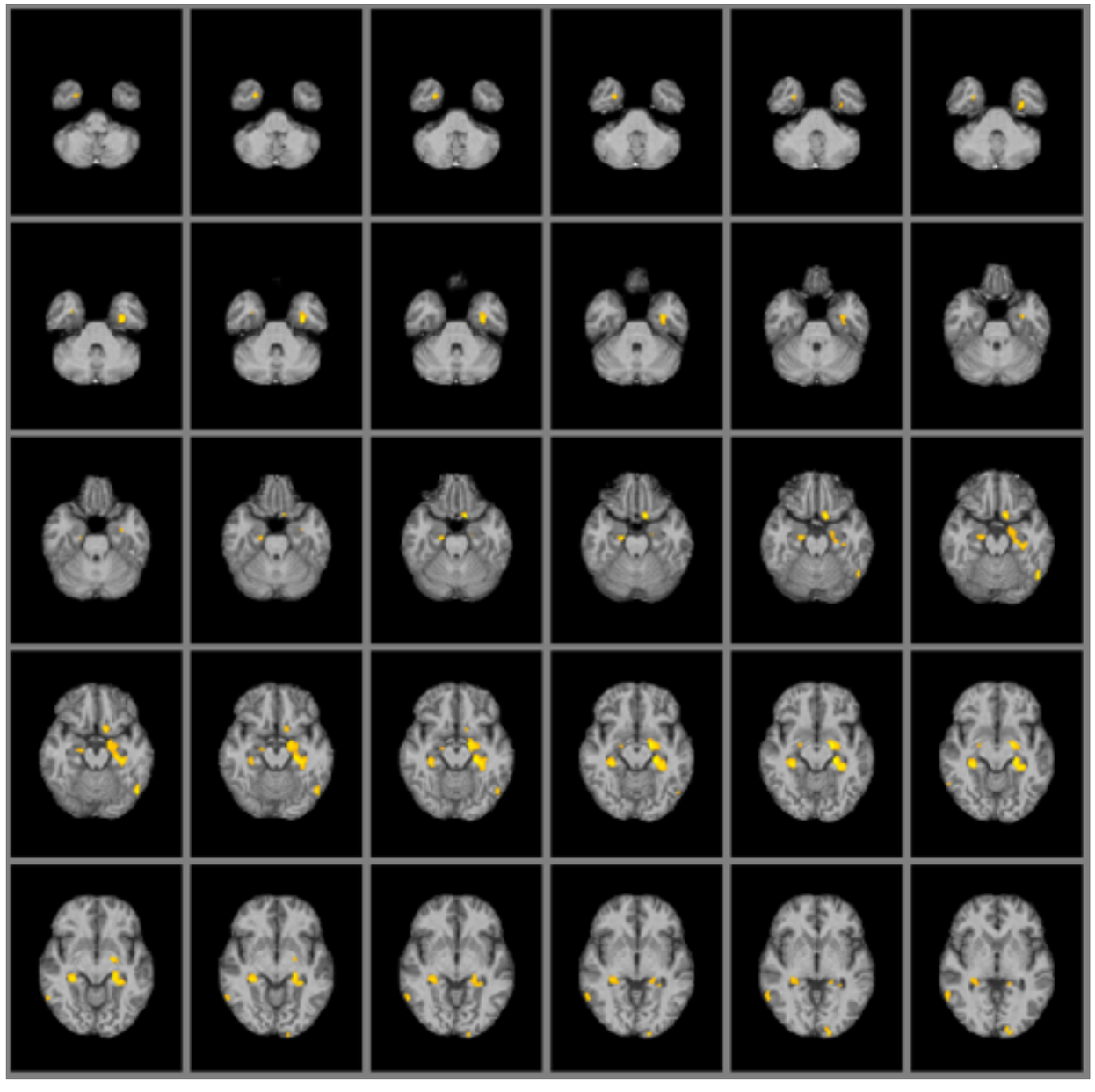
Masking:

The region you want to do statistical inference (Absolute, implicit and explicit)

Statistical result of our question !

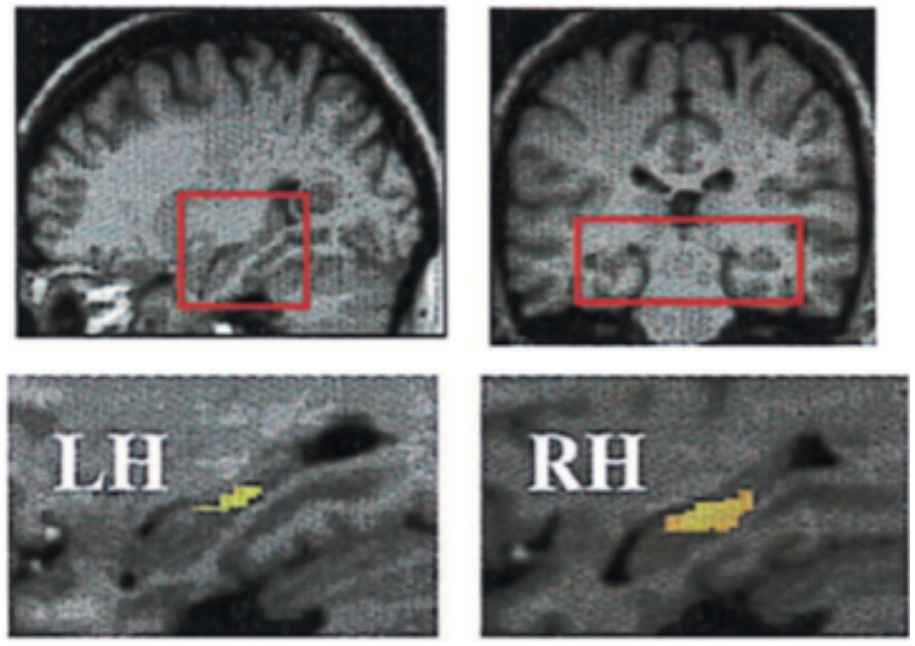


un-thresholded map

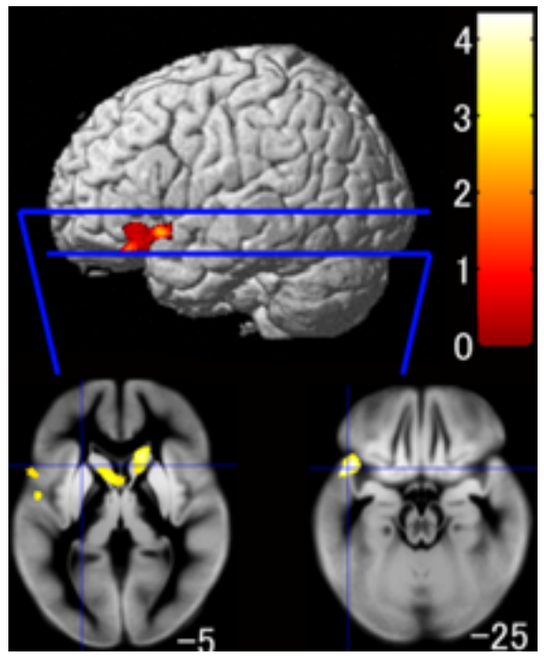


thresholded map

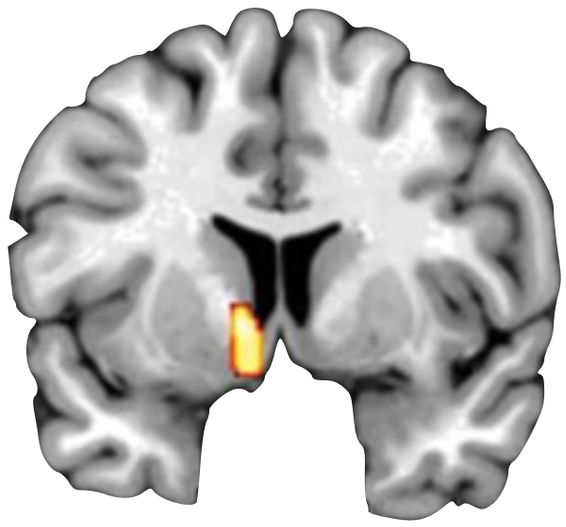
Additional real-world examples using 2 sample T-test design



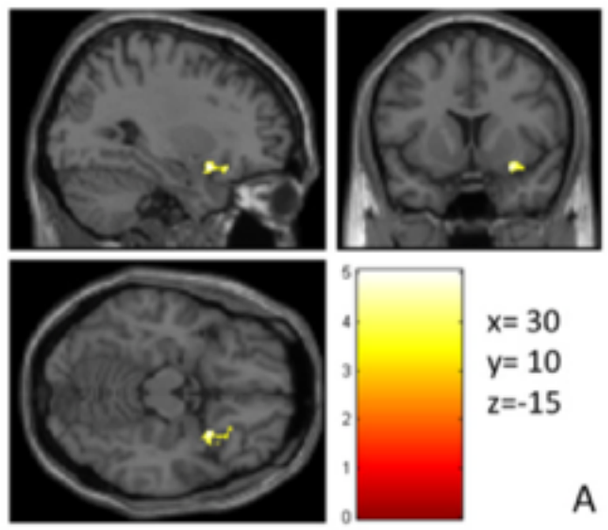
London taxi drivers vs. control subjects



rice for breakfast vs. bread for breakfast

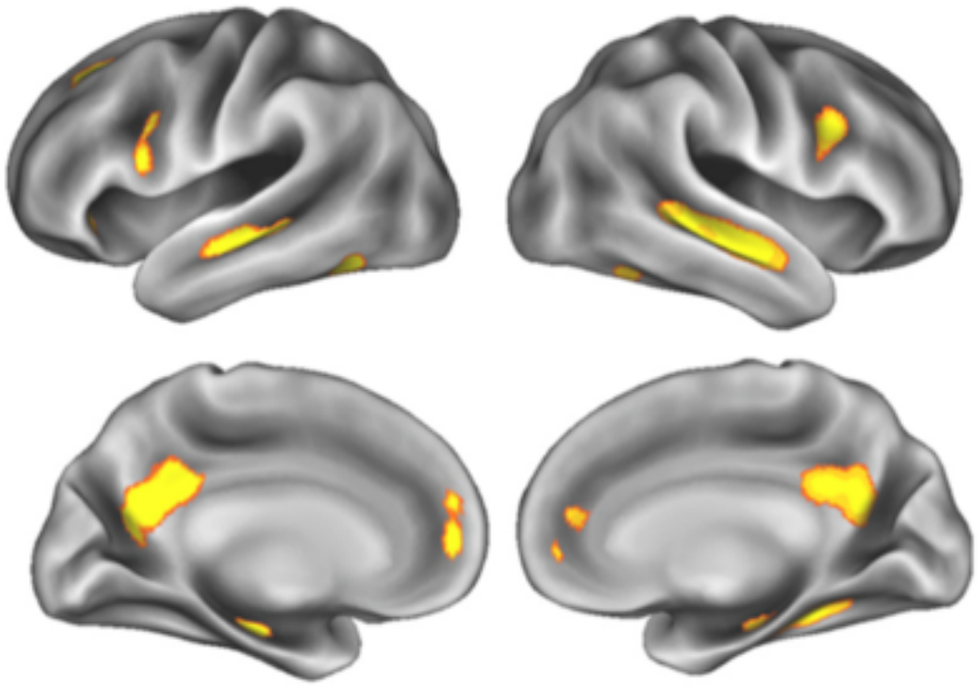


Frequent vs. infrequent video-gamers

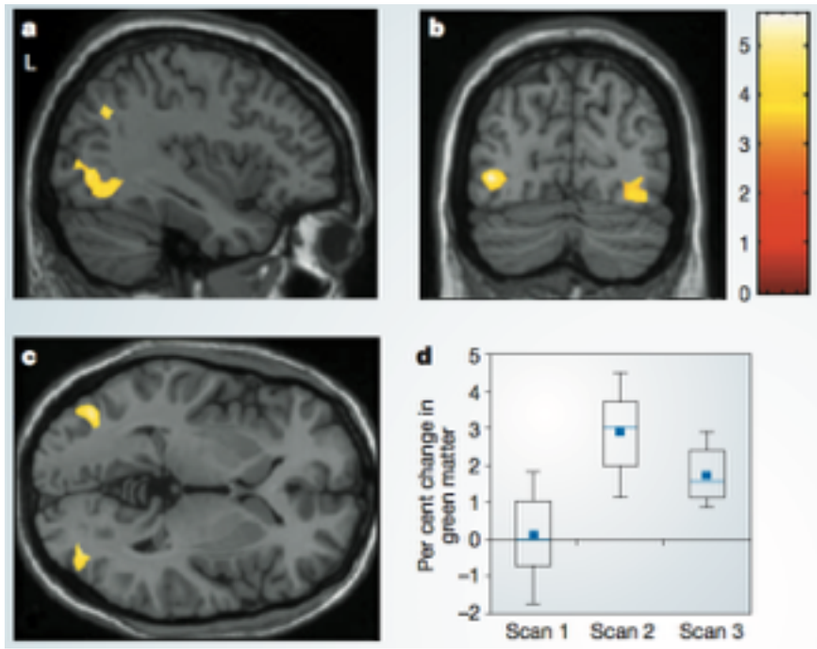


Yoga meditators vs. non-meditators

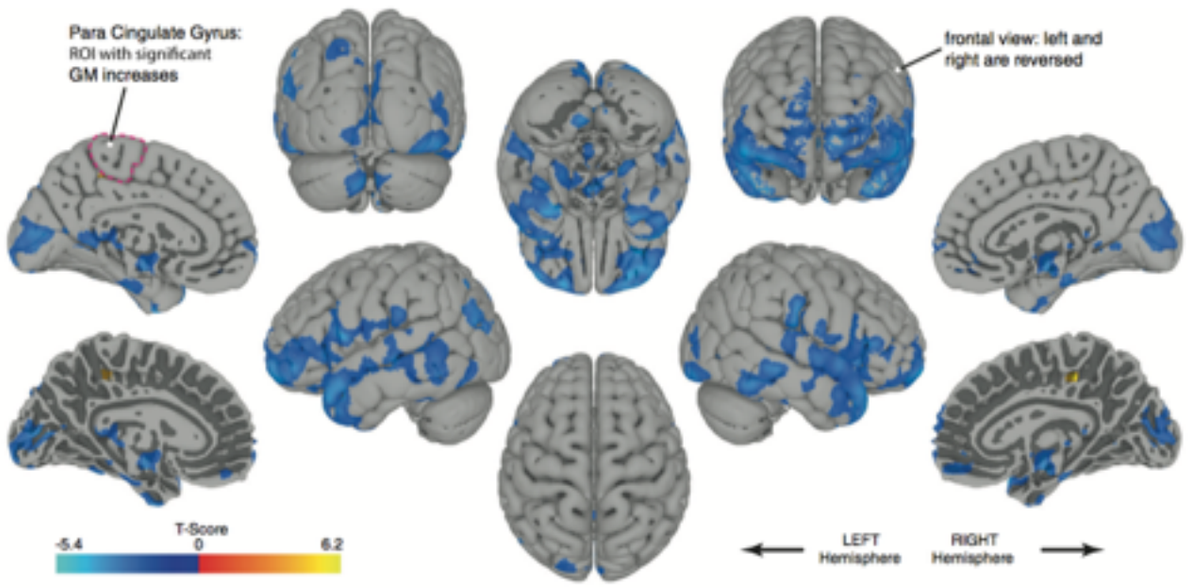
We may also care about before - after effect ……



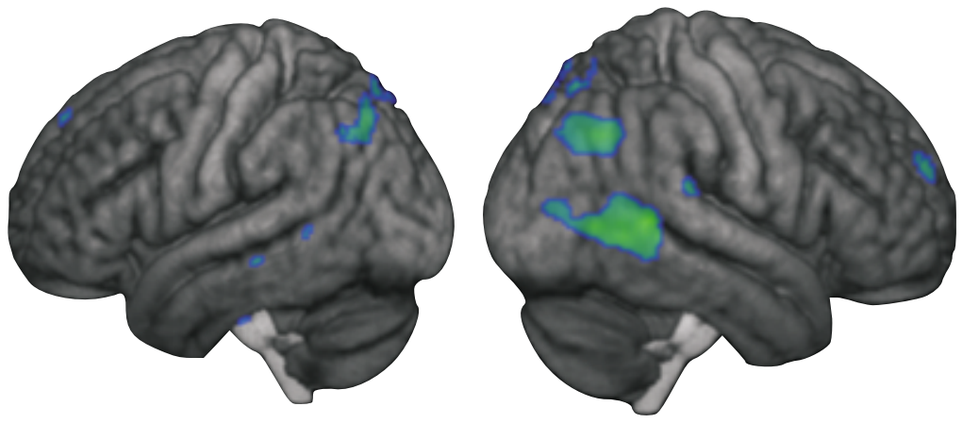
pre-pregnancy vs. post-pregnancy



Pre-training vs. post-training



pre-space flight vs. post-space flight



Before-ultra marathon vs. after 4001 km

Hoekzema et al.
Nature Neuroscience. 2017.

Draganski et al.
Nature. 2004.

Koppelmans et al.
npj Microgravity. 2016.

Freund et al.
BMC sports science, medicine & rehabilitation. 2014.

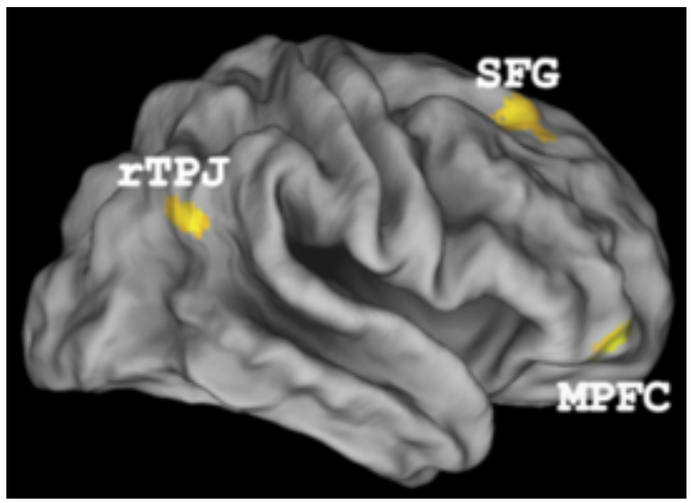
Or different experiment effects in single study group

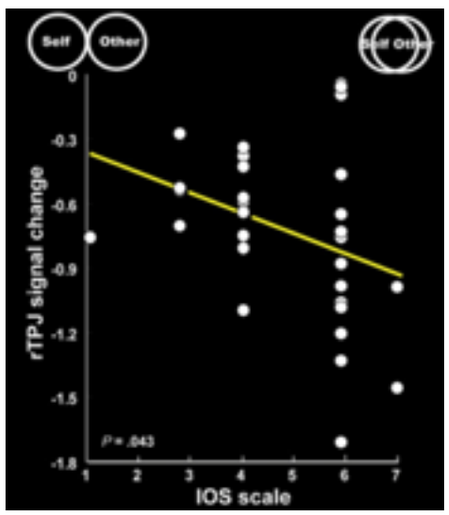
Painful

Non-painful

Painful

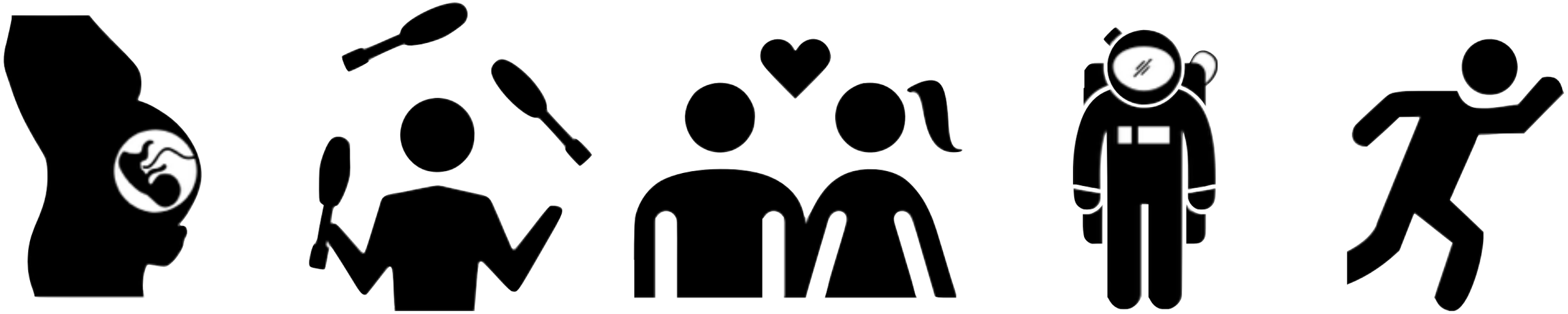
Non-painful





Love can be measured !?

Deconstructing the framework of scientific papers !

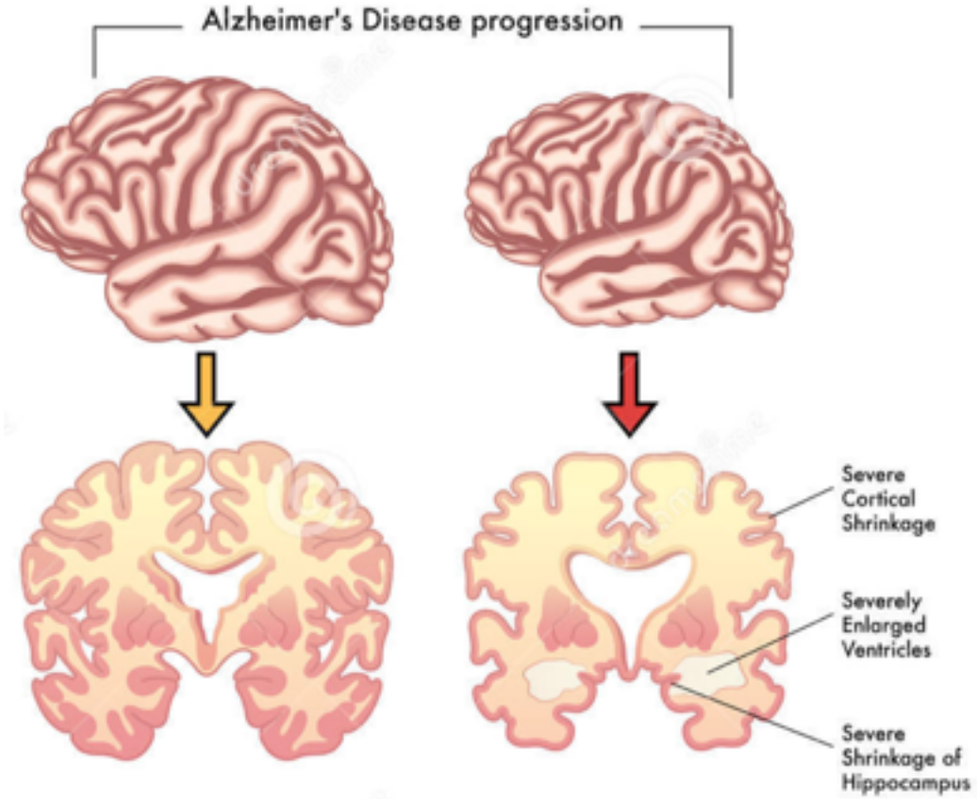


Experimental, intervention, medication and time effect in single group……

[Pair T test]

Example 2:

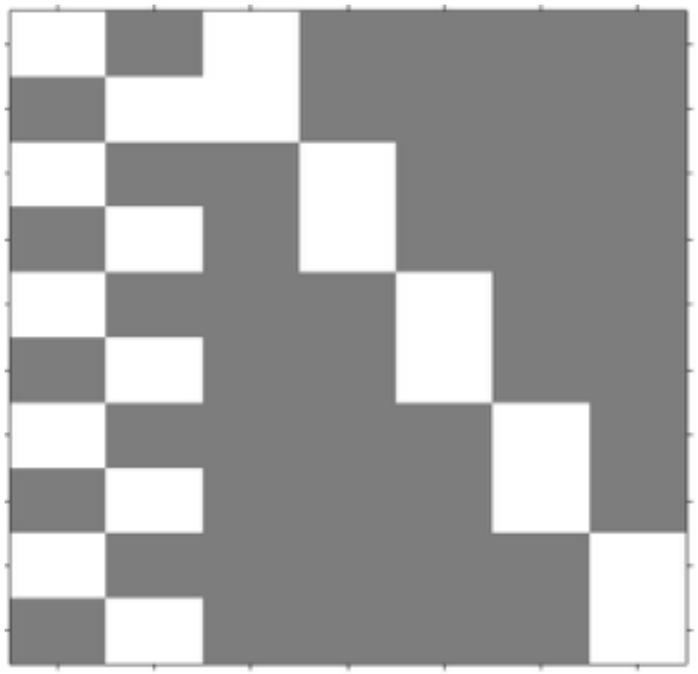
Gray matter volume atrophy in patient with Alzheimer’s disease !?



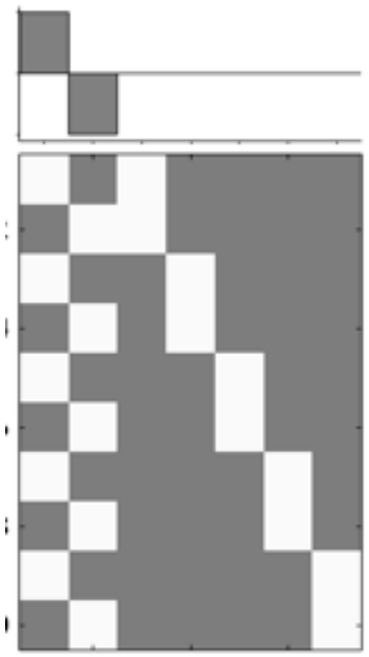
Longitudinal GMV changes in patients with Alzheimer's Disease

"Is there significantly lower gray matter volume in the follow-up scan than in the baseline scan of the patient with Alzheimer disease?"

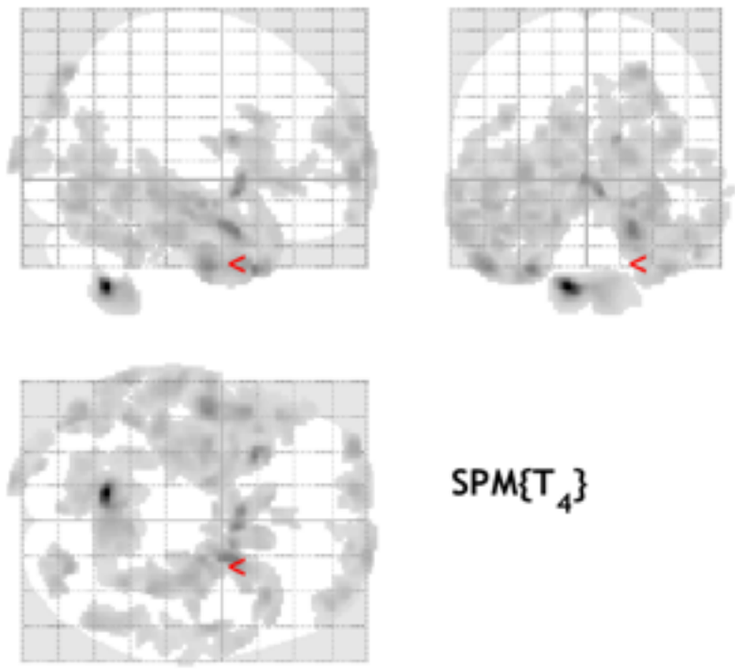
$$Y = \beta_1(\text{baseline}) + \beta_2(\text{follow-up}) + \beta 3(\text{within-subject 1 effect }) + .. + \beta n(\text{within-subject n effect}) + \varepsilon$$



Model construction



Statistical inference



Result visualization

Pair T-test (Model Construction)

Current Module: Factorial design specification

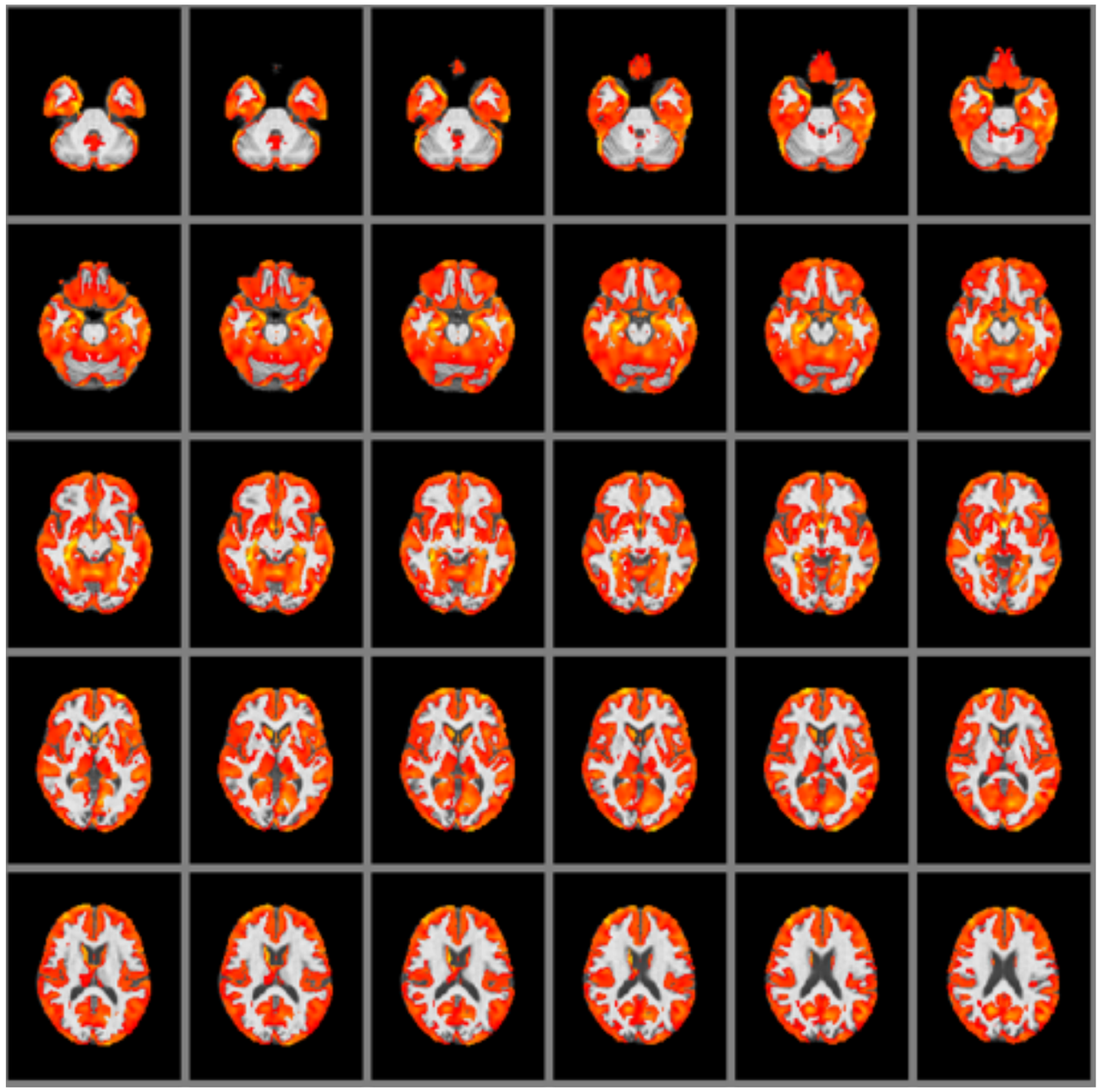
Help on: Factorial design specification	
Directory	...ield/NTU_SPM_Statistical_Course_Demo/2_Pair_T_Test/3_Statistical_Modeling_VBM
Design	
. Paired t-test	
. . Pairs	
. . . Pair	
. . . . Scans [1,2]	2 files
. . . Pair	
. . . . Scans [1,2]	2 files
. . . Pair	
. . . . Scans [1,2]	2 files
. . . Pair	
. . . . Scans [1,2]	2 files
. . . Pair	
. . . . Scans [1,2]	2 files
. . Grand mean scaling	No
. . ANCOVA	No
Covariates	
Multiple covariates	
Masking	
. Threshold masking	
. . None	
. Implicit Mask	Yes
. Explicit Mask	...eld/NTU_SPM_Statistical_Course_Demo/2_Pair_T_Test/4_Mask/Final_GM_Mask.nii,1
Global calculation	
. Omit	
Global normalisation	
. Overall grand mean scaling	
. . No	
. Normalisation	None

Directory: The output directory of your statistical model

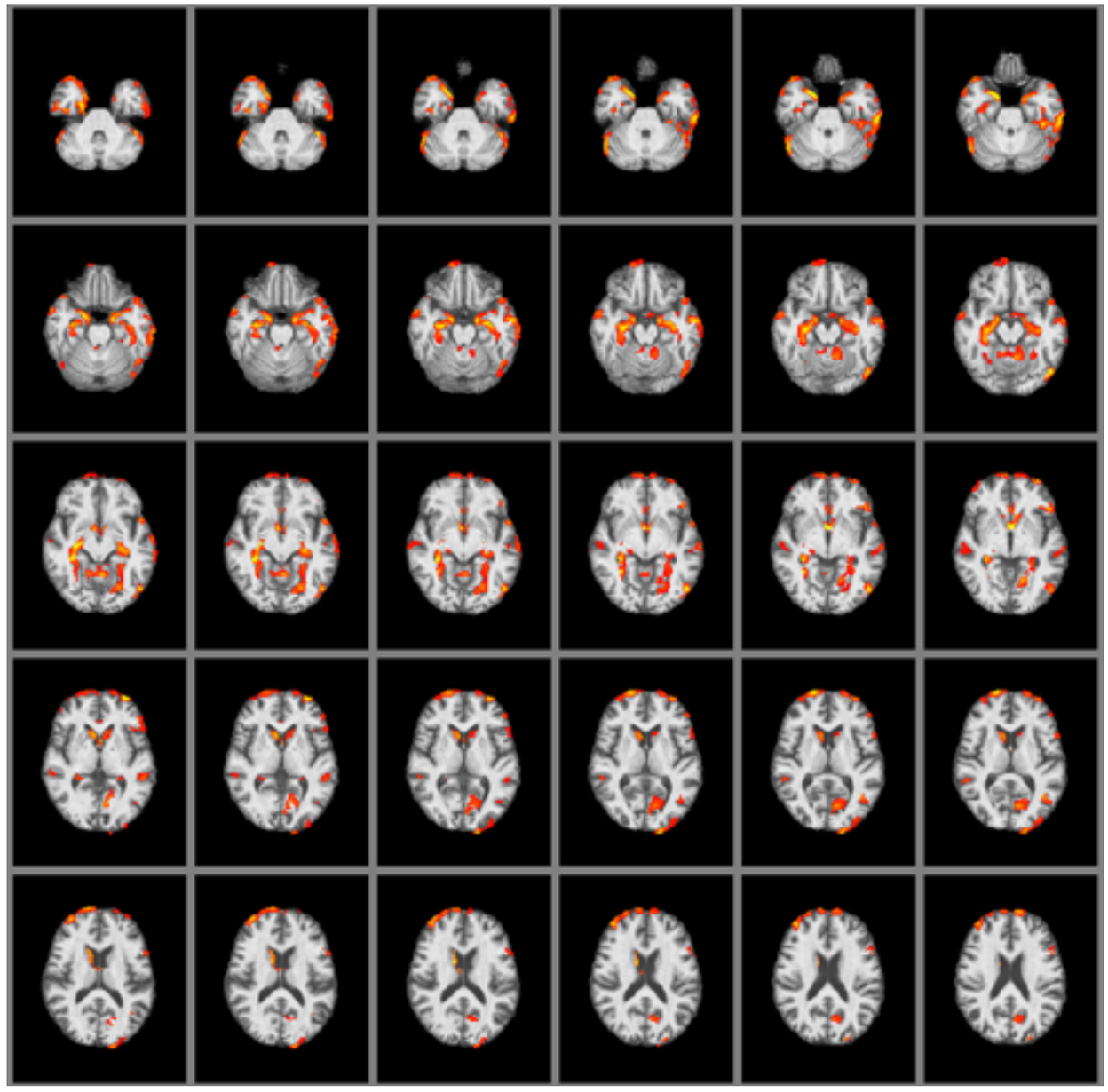
Design: The statistical model you want to use (Pair T-test)

Masking: The region you want to do statistical inference

Statistical result of our question !



un-thresholded map

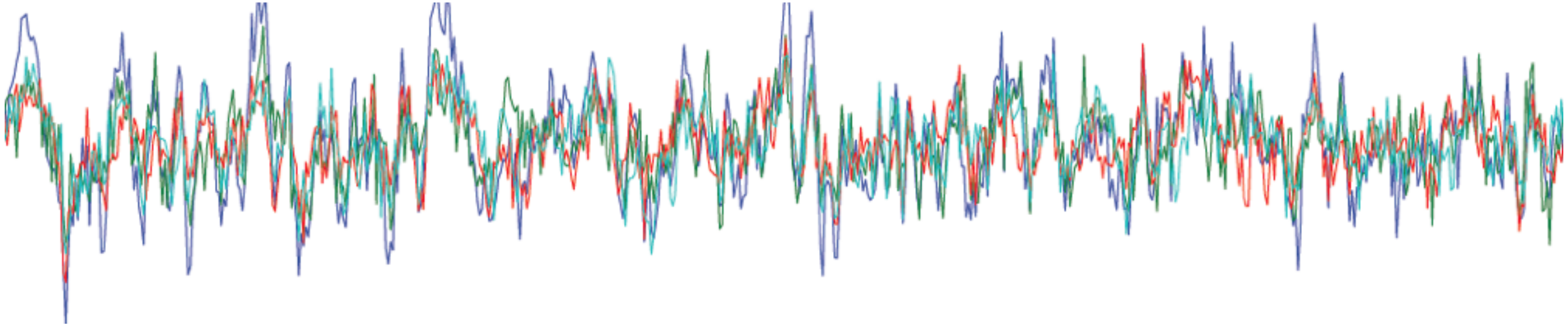


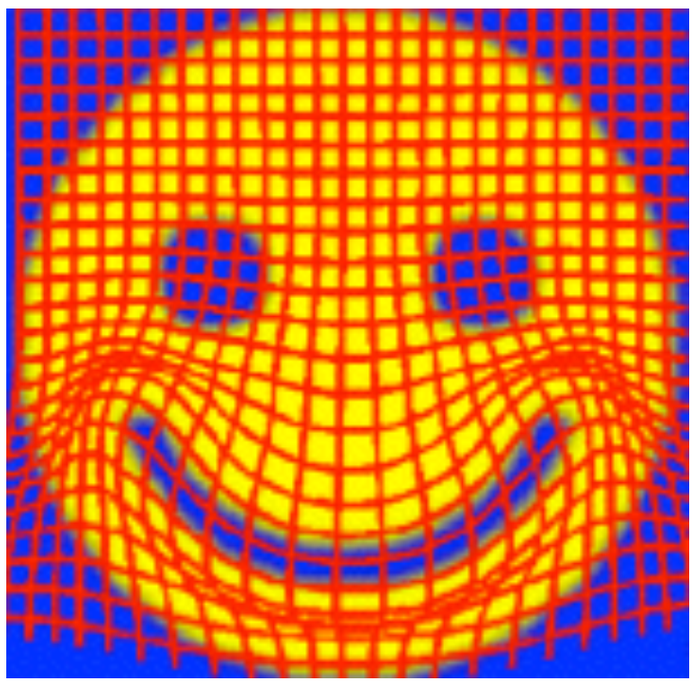
thresholded map

TL;DR

Number of factor levels	Number of covariates	Statistical model
1	0	One-sample T-test
1	1	Single regression
1	> 1	Multiple regression
2	0	Two-sample T-test
> 2	0	ANOVA
> 2	> 0	ANCOVA (full factorial)

Special case : Pair-T test (before-after effect in single group)





Thanks for your attention !!

dargonchow l@gmail.com