Estimation of Statistical Power in a Multicentre MRI study.

Benson Mwangi Irungu

PhD Student,Centre for Neurosciences
Ninewells Hospital and Medical School
University of Dundee.

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- Power is the probability of rejecting the null hypothesis when it is false.

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- Pooling data from multiple centres introduces scanner related variances.
- Statistical power is bound to change depending on which region of the brain is being analyzed e.g. regions of activation in fMRI or structural differences in sMRI.
- This makes MRI power analysis rather more difficult than in a typical behavioural measure.

Demographics:

- MRI data acquired in 2 centres (Centre I- Aberdeen , Centre II- Edinburgh).
- All patients had been diagnosed with DSM IV Unipolar major depression.
- Controls were matched based on average age, male/female ratio and estimated IQ.
- Images acquired using 1.5 T General Electric MRI scanners in both centres.

Table: Demographic information

Variable(Mean/SD)	Patients#I	Controls#I	Patients#II	Controls#II	Significance (P-Value)
Age (Yrs)	46.07	40.59	44.66	42.99	p=0.597
Females/Total	9/15	11/18	10/15	7/14	p=0.411
NART	111.6	114.33	115.67	117.69	p=0.566
BDI	22.93	3.15	38	1.14	p<0.001
SP	54.6	30.38	62	28.79	p<0.001
SH	35	51.36	32.13	52.71	p<0.001
Hamilton	23.2	-	27.87	-	p=0.19

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Smoothing

- A Gaussian FWHM window of 8-mm used for smoothing.

Voxel-wise Statistical Analysis

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Essentially, the following hypothesis were tested:

1. Structural differences between control/patient groups in each centre.
2. Scanner related differences- differences between controls from both groups.
3. Overall structural differences between controls and patients pooled from both centres.

Voxel-wise Statistical Analysis

Factorial Design:

Design Matrix

	control I	patient I	control II	patient II
control I	1	0	0	0
patient I	0	1	0	0
control II	0	0	1	0
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- Centre I- [-1 1 0 0], patients > controls
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  Threshold of significance:
- $p<0.05$ corrected at a whole brain cluster level using a Monte Carlo method (Slotnick et al)

Structural and scanner Differences-Results

Centre I: Controls vs Patients

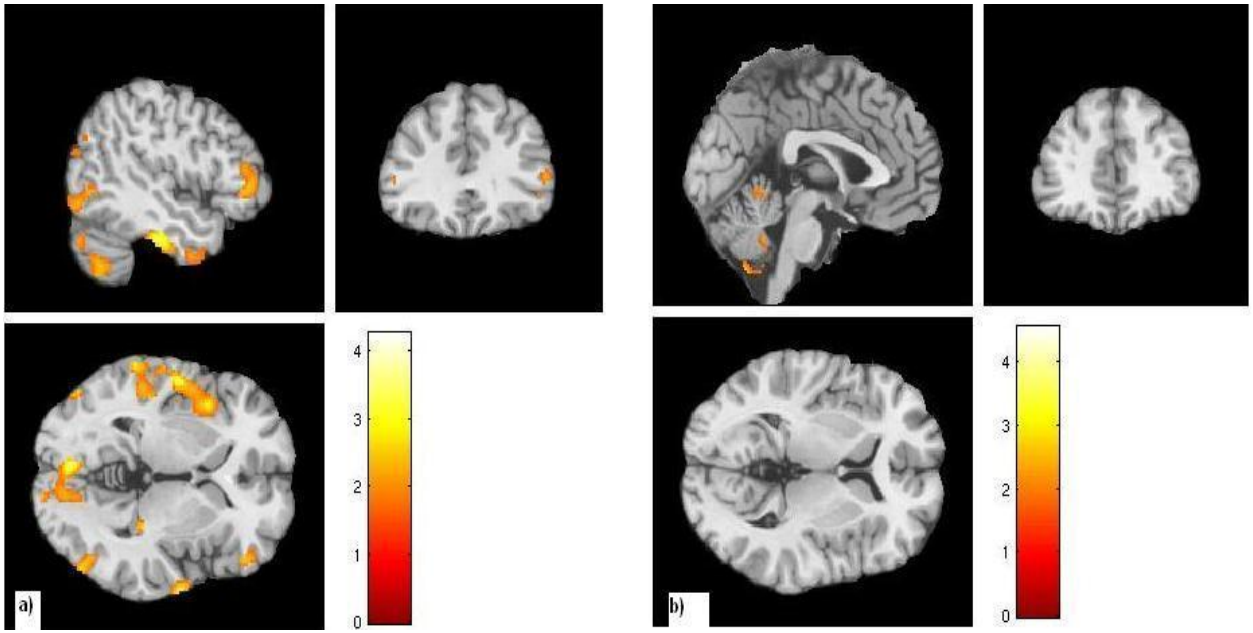
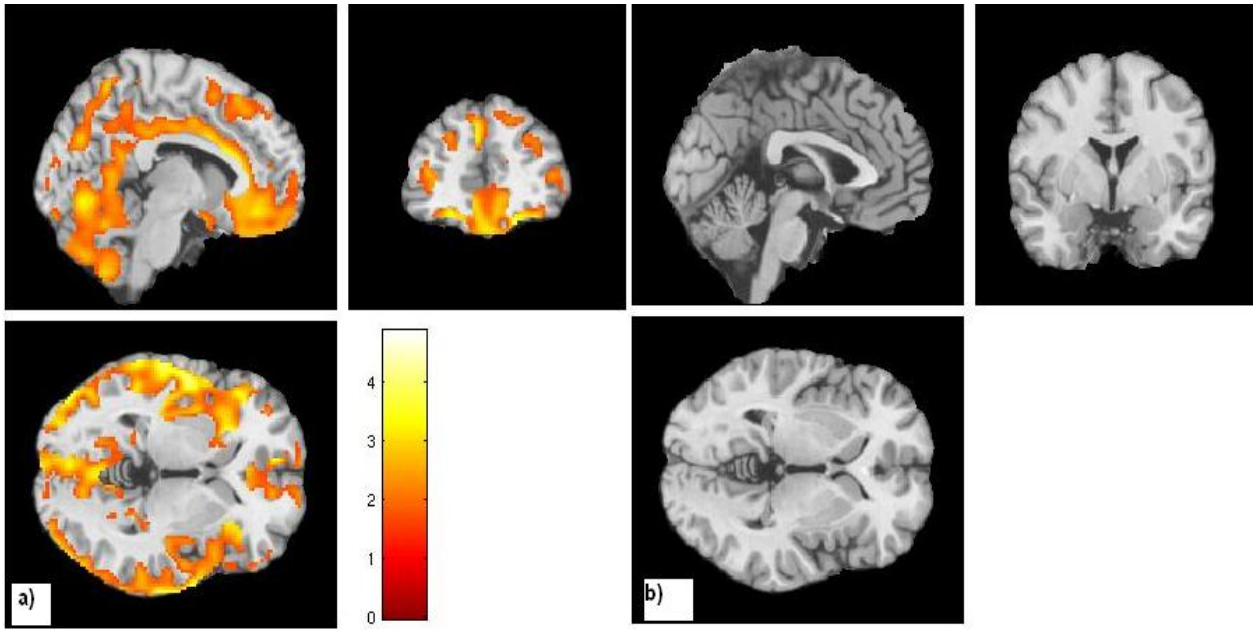


Figure: Structural differences between patients and controls a) Patients had reduced grey matter density, b) no evidence of increase in grey matter density in the patient group.

Structural and scanner Differences-Results

Centre II: Controls vs Patients



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Scanner Differences:Centre I>Centre II.

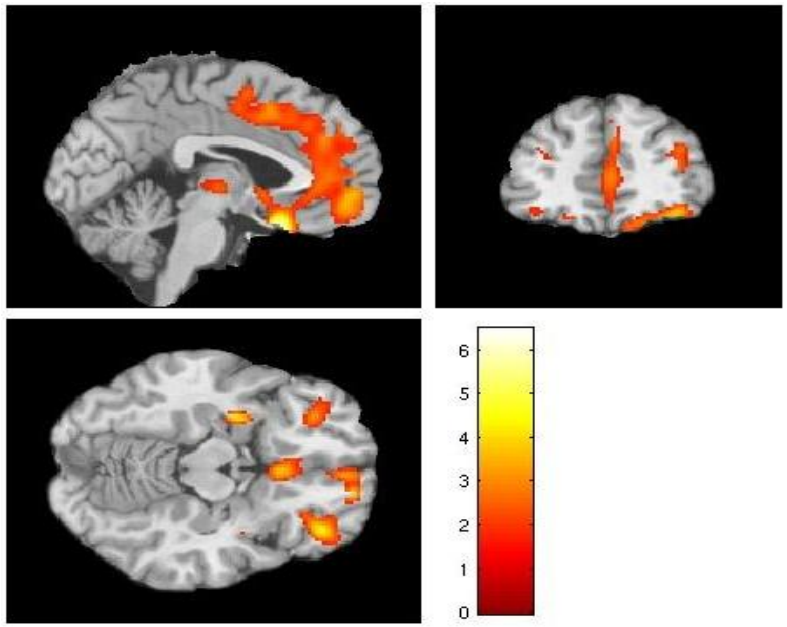

Figure: Scanner differences between scanner I and scanner II and whilst it might be a subject effect we think it's more likely a scanner effect.

Data Pooling:

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Factors which would influence the power outcome include:

1. Sample size
2. Effect size
3. Type I error e.g. $\alpha = 0.05$- (The odds that the observed result is due to chance)

Data Pooling

Do Z values go up?

Table: Significant cluster peaks : Centre I subjects

Region	Brodmann Area	MNI Coordinates	Z-value
Superior temporal gyrus	22	-64,-14,6	3.04
Precentrall gyrus	6	-50,-2,8	2.99
Superior temporal gyrus	38	-48,8,-14	3.20
Inferior frontal gyrus	45	-50,22,14	3.08
Middle frontal gyrus	47	48,38,0	2.32

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Table: Significant cluster peaks: Centre II subjects

Region	Brodmann Area	MNI Coordinates	Z-value
Middle temporal gyrus	21	64,-4,-6	4.44
Inferior frontal gyrus	11	-20,28,-24	4.28
Superior temporal gyrus	38	48,12,-14	3.66
Superior temporal gyrus	38	-56,4,-6	3.84
Superior frontal gyrus	9	-8,50,34	3.94

Data Pooling

Do Z values go up?-Pooled data:

Table: Significant cluster peaks: Pooled data

Region	Brodmann Area	MNI Coordinates	Z-value
Superior temporal gyrus	22	-58,-6,0	4.69
Middle temporal gyrus	21	64,-4,-4	4.49
Superior temporal gyrus	22	-54,0,-4	4.34
Middle Occipital gyrus	19	-50,-60,-8	4.42
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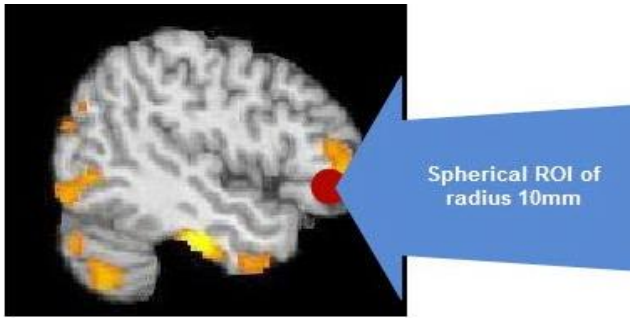
- Increased power is suggested by higher Z values.

Effect Size and Power calculation

Steps:



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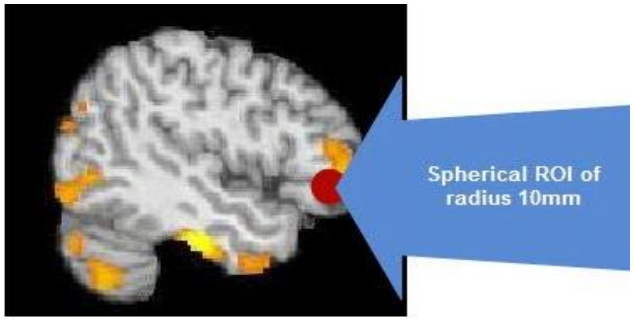

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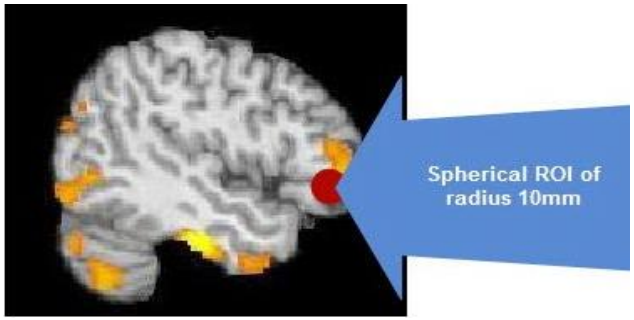

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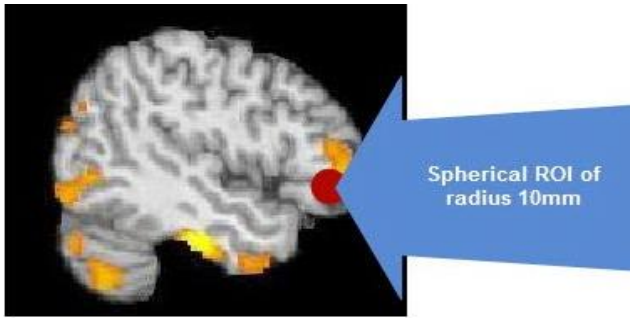

1. A spherical region of interest (ROI) is selected by centering around a particular cluster point where significant structural differences were detected.
2. The mean representing all voxels around the ROI is computed.
3. Computation of effect size and study power for the contrasts of interest using Gpower 3

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- N = total sample size (e.g. 62), n= sample size in group i (e.g. 4).

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- Offers five different types of statistical power analysis i.e. apriori, compromise, criterion, **post hoc** and sensitivity.
- Inputs to the software include: Effect size, Alpha error probability, Total sample size, numerator degrees of freedom and number of groups.

Effect Size and Power Calculation

Power Calculation Results centre I , centre II:

Table: Power calculation results:Centre I

Region	Brodmann Area	ROI centre MNI Coordinates	Effect size	Statistical Power
Middle temporal gyrus	38	-42,4,-44	0.2725	0.5596
Insula	13	-44,14,0	0.2691	0.5393
Superior temporal gyrus	22	64,-14,6	0.3021	0.6477

Table: Power calculation results:Centre II

Region	Brodmann Area	ROI centre MNI Coordinates	Effect size	Statistical Power
Middle temporal gyrus	38	-42,4,-44	0.3435	0.758
Insula	13	-44,14,0	0.2055	0.3563
Superior temporal gyrus	22	64,-14,6	0.2938	0.6236

Effect size and power calculation

Power Calculation Results Pooled Data:

Table: Power calculation results:Pooled data

Region	Brodmann Area	ROI centre MNI Coordinates	Effect size	Statistical Power
Middle temporal gyrus	38	-42,4,-44	0.4348	0.9202
Insula	13	-44,14,0	0.3364	0.7404
Superior temporal gyrus	22	64,-14,6	0.4229	0.9050

As a result:

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- The effect sizes for all three planned ANOVA contrasts are therefore in the small to medium range.
- There is a benefit to pooling data in all regions of interest and the likelihood of rejecting the null hypothesis increases with pooled data.

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- Efforts towards scanner harmonisation should be encouraged.
- Initial results from two of the multicentre based studies indicate that multivariate pattern recognition techniques are not largely affected by scanner related variability kloppel., et al 2008-Alzheimer's disease study ,Mwangi, B., et al, 2010- Unipolar major depression study.

References

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