fMRI in theory and practice

...and what connectionist modellers and brain imagers have in common

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Overview

Part One: fMRI in theory and practice

• Principles
• Designing a study
• Data collection
• Data analysis

Part Two: fMRI & Connectionism

• fMRI & connectionism working together
• What fMRI & connectionist modelling should have in common
• Conclusions
fMRI: some principles

- **The Blood Oxygenation Level Dependent signal (BOLD)**
  - An indirect measure of neural activity:

Source: fMRIB: Brief Introduction to fMRI – www.fmrib.ox.ac.uk/fmri_intro/physiology.html
The Hemodynamic Response Function

• Signal takes 4-6 seconds to peak after stimulus onset
• Signal changes between 0.5 and 3% \( \frac{\text{point} - \text{baseline}}{\text{baseline}} \)

Study Design

• Your hypothesis
• Regions of Interest (ROI)
• What conditions/tasks?
• Duration and sequence of tasks
• Number and length of runs
• Counterbalancing: within/between subjects
• Potential confounds: eye movements, motor movements, attention

» more…
• Volume acquisition time
• Number of slices
• Slice orientation
• Slice thickness
• In-plane resolution
• Voxel size

Voxel illustration from fMRI for dummies
Collecting the Data

• When participants take part in our study we take two types of brain images…

**Functional scans**: record task related activity  

**Structural scans**: detailed anatomical picture of the brain
**Functional scans**: many pictures taken at low resolution at high speed

**Structural scans**: one high resolution image

i.e., 1 Volume = 1 whole brain can be acquired in 3 seconds
…going into the scanner

Metal check
Safety questionnaire
The scanning room
Comfort and communication
Equipment set-up
Tasks in the scanner… an example

• Each task has an *activation* and a *baseline* condition

• 3 different types of task:
  – Read silently for meaning
  – Read aloud
  – Hand movements
Data Analysis: the process in brief

From: Human Brain Function, Frackowiak et al., 2003: p601
Part 2: fMRI & connectionism

Reading: fMRI & connectionism working together

- Representations of visual word forms
  - VWF: the combination of letters that make up the word

- Representations stored in a specific functional module?

Or

- Emergent, as a combination of orthographic, semantic and phonological processing
Seidenberg and McClelland (1989)

Plaut, McClelland, Seidenberg and Patterson (1996)
What fMRI & connectionism should have in common

- Activations in connectionist models are motivated by and dependent on the task the network is required to do

- In brain imaging, the task should also be taken into consideration during data interpretation…
An Example from:
The Myth of the Visual Word Form Area

• “Visual Word Form Area” (VWFA), posterior region of the left midfusiform gyrus
  – VWF: is the combination of letters that make up the word
  – Lesion studies associate this region associated pure alexia
  – Cohen et al. (2002) showed that the same area was more responsive to written words than consonant letter strings
Reading

Manipulate pictures of objects

Read Braille with abstract meanings

z = -15  y = -57  x = -42
Summary

• Left midfusiform area is involved in visual word processing
But…
• Area is not specific to visual word forms
• It is important to test on multiple tasks before concluding that a region is dedicated to a specific task
Conclusions

• fMRI requires multiple and competing hypotheses for testing
• Connectionism is a useful tool for formulating and test-driving these hypotheses
• Theories of information processing from fMRI can be tested using connectionist models
The End

Thank you for listening