2021 fMRI Training: fMRI Experimental Design

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1. A basic plan for an fMRI study
   (1) Research question (novelty? Importance?)
      - How information processing is implemented in the brain?
      - Technology: Why (f)MRI?
   (2) Hypothesis (define mental process to examine)
      - Neural hypothesis: brain regions and neuronal responses
      - Hemodynamic hypothesis: , BOLD signals and linearity
      - Psychological hypothesis: how a given manipulation (independent variables) should change measurements (dependent variables)
        (A) (induce) psychological state(s)
        (B) Detect brain signals related to the psychological states
      - Statistical hypothesis: multiple comparisons
   (3) Experiment (design task to manipulate that process):
      - Task-positive and task-negative
      - Independent variables and dependent variables
      - Between-subject or within-subject (or repeated measure)
      - Tasks
        (A) Conditions (independent variables)
        (B) Sessions and runs
        (C) Blocks and trials
        (D) Events, stimuli and responses
      - Designs: block and event-related.
        (A) Block design: similar events are grouped
        (B) Event-related design: events are mixed (or jittered).
   (4) Data acquisition (measure BOLD signals and behavioural data)
      - Operating status of the system and set-up
      - Preparation of the participant (safety)
      - Localization
      - Structural T1 scan
      - Functional EPI scans (multiple runs)
      - Head movements
      - Behavioral responses

(5) Analyses, statistics and inferences

2. Design considerations
   (1) Inefficient experimental designs?
      - Poorly matched to the research hypothesis
      - Unclear manipulation
      - Correlation in order
      - Correlation in time
   (2) What should we control?
      - Individual difference: matching and random assignment
      - Timing (or intervals): randomization
      - Event or trial orders: randomization or counterbalance
      - Instructions and response bias (participants' strategies)
      - Combined techniques: fMRI + MEG, fMRI+EEG
   (3) How to optimise our fMRI design
      - Specific hypothesis
      - To maximize the size of effect: scans, participants, idea interval

3. Other considerations
   (1) Participants: metal-free, large numbers (as many as possible), sleepy, training.
   (2) Experimental time: about 50-60 minutes.
   (3) Multiple runs with many short breaks.
   (4) Always look at head movement and behavioural responses throughout the experiment.

4. Six basic rules for fMRI experimental design (Huettel, Song, McCarthy, 2004, Functional Magnetic Resonance Imaging)
   (1) Evoke the cognitive processes of interest
   (2) Collect as much data as possible from each subject
   (3) Collect data from as many subjects as possible
   (4) Choose your stimulus conditions and the timing of their presentation to evoke maximal changes in the cognitive processes of interest, over time
   (5) Organise the timing of experimental stimuli so that successively elicited processes of interest are minimally correlated with each other, over time
   (6) Where possible, obtain measurements of your subjects' behaviour that can be related to the fMRI activation