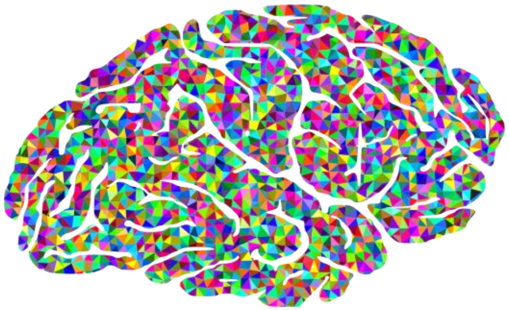

Good practice in food-related neuroimaging

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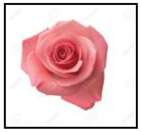
Background

BOLD fMRI provides an indirect vascular measure of neuronal activity information on which brain regions become more or less active during a certain task and whether this differs between study conditions.

Recent focus:
-Functional connectivity and functional interactions (the degree to which task related brain activation in a specific brain region covaries with activation in other brain regions)
-Individual differences in neurobiology: "Resting-state" fMRI, which examines the spatio-temporal networks of correlated activity in the absence of a specific task (lying still with eyes closed, or mere visual fixation).

-The brain is central in the regulation of food intake and body weight,
-In the past 2 decades fMRI is more used to study food behavior (explore neural correlates of food behavior in healthy and pathologic individuals)

Using simple tasks:
-a good effect size
-robuste
-reliable



vs
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Using more complex tasks:
-smaller effect size
-less robuste
-less reliable

-Poor reliability even with simple paradigms (40% of studies)

Aim of the review

Putative factors of variability

Study design

- Structure
- Timing
- Stimuli
- Srategy
- Statistics parameters

Individual characteristics

- Age
- Gender
- Eating related traites (hunger, weight status…)
- Personal traits

Confounding factors

- Influence the effect size (ex: caloric content/palatability, familiarity with tested food…)

1. Propose guidelines to foster good practices in food related neuroimaging
2. Outline the major limits
3. Provide recommadations for studies improvment and task implementation

Based on Appendix D of the COBIDAS report.
Committee on Best Practice in Data Analysis qnd Sharing

Before data acquisition

Study design

The vast majority of nutritional neuroimaging studies are cross-sectional

Difficulty in drawing inferences

It is crucial **to promote long-term follow-up studies** (e.g., by adding MRI measures to adequately powered cohort studies).

Baseline or **“resting-state”** brain activity may differ between individuals (or groups)

Power calculation

High prevalence of underpowered studies in neuroimaging

Inconclusive, nonreplicable, or
misleading findings

Use **fMRI-specific tools** to make appropriate power calculations that incorporate both within- and between-subjects factors.

Mumford JA. A power calculation guide for fMRI studies. Soc Cogn Affect Neur 2012

Remember that power is a function of **the number of participants** but also of the **heterogeneity of the study population** and the **amount and quality of data collected** per participant.

Complemente by **piloting the exact experimental procedures** (to avoid publication bias)

Definition of factors and task design

 Define precisely which factors were controlled and which were manipulated.

Hunger state and related factors: affect food wanting and food-related brain responses

Personal characteristics: personality or cognitive traits may modulate food-related brain responses
Control statistically for subclinical scores on eating-disorder scales.

Choosing and matching food-related stimuli: Eating engages all of our senses.
The choice of stimulus will depend upon the particular goals of the study. sup 2

Optimize the design of fMRI tasks in terms of **the number, temporal distribution, and duration of different trial types**
e.g of a tool for testing efficiency of an fMRI task design, see http://www.neuropowertools.org/

Information related to participants

- -Age
- -Gender and test for possible effects
- -Handedness and account for nonrighthandedness in analyses
- -BMI or age-adjusted BMI and test for possible effects

- -Menstrual cycle phase and how this was accounted for in the analysis

- -Race and ethnicity
- -Socio-economic status
- -Physical activity level
- -Use of relevant medication
- -Further adiposity measures
- -Measure of dietary restraint
- -Measure of stress
- -Personality traits such as reward sensitivity and impulsivity

Mandatory
Highly recommended
Recommended

Eating disorder scales

- Report time since last meal

-Report weight history; weight lost or gained in the weeks before brain imaging
- Report appetite ratings

-Standardize the last meal before brain imaging
-Report thirst ratings

Mandatory
Highly recommended
Recommended

Study design and procedure

-Describe the hunger state(s) and how they were achieved
-Report food stimulus details including macronutient composition and energy content
-For pre- compared with postfeeding studies, motivate why fasted and fed conditions could not be completed on separate
days to avoid order effects

Mandatory
Highly recommended
Recommended

fMRI task

- Report the task instructions
- Report the number and timing of the task events and how their order was randomized and/or optimized
- Describe the stimuli used and how they were matched, e.g., on visual characteristics

-Provide a power calculation

Mandatory

Highly recommended

Recommended

During data acquisition

The influence of movements

- fMRI data are prone to movement-related artifacts
- In particular, oral stimulation can be accompanied by significant movement.

Displacement and distortions in the data

Counteracted the movements influence **in real time** or **modeled post hoc** during data analysis.

a) Real time.

Use of cushions around the head or a bite bar.

Behavioral training to learn to swallow with minimal movement of the head

Provide the participant with a stationary reference to be aware of the movements

b)Post hoc analysis.

Correction for head motion via image registration >> not sufficient

Include intensities motion parameters as nuisance regressors in the statistical model >> still insufficient

The influence of the context

- The context of the experiment activates associated information and influence the current goal
- fMRI food choice tasks are very different from the real-life food-choice environment

Low ecological validity

Mention whether the experiment was carried out at a **hospital or at a research-dedicated MRI** scanner in a nonmedical facility

Development of more realistic fMRI paradigms which better reflect the reality of food cue exposure and choice

Develop more realistic fMRI paradigms by using **virtual reality** >> increased realism = increased noise and excessive visual stimulation

After data acquisition

fMRI data analysis

Statistical thresholding for whole-brain and regions of interest.

Common use of the rule-of-thumb corrections for multiple comparisons

Inadequate in controlling false-positive rates

Permutation-based procedures is the best choice of correction methods for multiple testing in fMRI data.

Cluster-based methods should be used correctly

ROI analyses must be planned a priori, ideally preregistered, and the hypotheses about the region must be clearly stated.

fMRI data analysis

Statistical thresholding for whole-brain and regions of interest.

 Univariate approach involves the repeated testing of a regression model in tens or hundreds of thousands of individual voxels.
These multiple tests require corrections for multiple comparisons that reduce statistical power.

Reduced statistical power

Use **multivariate analyses**

Data-reduction or **aggregation** techniques (independent or principal-components analyses, or predefine regions of interest)

fMRI data analysis

-Indicate how correction for multiple comparisons was done and how the threshold used was determined
-Test multiple ROIs with a single combined ROI mask

- Use appropriate covariates, such as stimulus liking, gender, menstrual cycle phase, and BMI

-Include blood parameters as covariates, if available

Mandatory
Highly recommended
Recommended

Appropriate interpretation

Common practice in the interpretation of neuroimaging results is the use of reverse inference

Not deductivly valid

Reverse inference should be used **with caution** and involve as much **specificity** as possible.

For **large and heterogeneous regions** (the insula, cerebellum, and prefrontal cortex) consider the exact subregion found in combination with the process of interest.

When comparing to findings of other studies, **check the exact location** before concluding to similarities.

Combination with other measures creates synergy and aids the interpretation of fMRI finding

fMRI data analysis

-Avoid reverse inference
-Be as specific as possible in the degree of overlap when comparing activated brain regions with regions found in other studies

Mandatory
Highly recommended
Recommended

Transparency and reproductibility

Preregestration to counter publication bias

Make more **use of existing data** or achieve greater yield from studies is to use the same paradigm and analysis pipeline across many centers

It is recommended to **share the unthresholded statistical images** from neuroimaging studies using a dedicated database e.g. Neurovault

Conclusion

To maximize the yield of neuroimaging methods, it is of paramount importance to adhere to high standards through the process of conducting a study

There is a need for more prospective and repeated-measures studies to:
- elucidate etiology of cognitive processes
- establish neural markers
- provide novel and specific targets for intervention.