HOW WE RECORD THE ELECTROGASTROGRAM (EGG)

We often get questions on how to record the EGG. Here is our how-to guide, which gives good results in most participants. Parts of this "recipe" might be mere superstitious beliefs, we certainly have not tried to vary all parameters. We hope this will come useful to those of you who want to give it a try. Feedback would be much appreciated!

1. PARTICIPANTS

- **SPECIFIC INCLUSION CRITERIA**

- Body Mass Index between 18.5 and 25 (« normal weight »). Note that we do not know whether this criterion is really important: on the one hand, the EGG might be more difficult to record in the presence of fat belly (cf Handbook of electrograstrography by Kenneth L. Koch and Robert M. Stern), on the other hand some articles report EGG measures in obese patients.
- No history of digestive disorders (Crohn's disease, Celiac disease or food intolerance, ulcer, heartburn/diarrhea/vomiting more than once a week, intestinal disease, gastric surgery…)
- Agree to have electrodes placed on their abdomen (above the navel, but it still requires to expose the abdomen, not all participants are comfortable with it)
- Hairy participants might be an issue (electrodes do not stick).

- **SPECIFIC PRE-RECORDING INSTRUCTIONS:**

- Avoid eating and drinking in the hour preceding the recording. The reason for this specific instruction is that we wish participants to have an empty stomach, so as to measure the activity of pacemaker cells rather than smooth muscle contractions. Stomach emptying takes about half an hour, duration depends on type of food/drink and participants. On the other hand, we do not want participants to suffer from stomach cramps, believed to correspond to large-amplitude traveling waves in the stomach.

2. SETUP

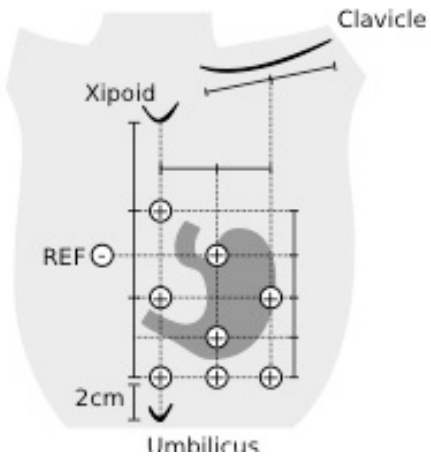
- **ELECTRODES**

- We use regular disposable cutaneous electrodes (6 to 8 active, 1 reference, 1 ground), of the same type as those used to record an electrocardiogram for instance. Stomach position varies quite a lot from participant to participant, hence the need for a number of electrodes covering the left abdomen. Ultimately we use only the electrode with the largest signal in a given participant.
- Standard procedure of skin preparation and impedance control.
- Electrode placement is described and shown below. We have used a number of montages, this is one example with a limited number of electrodes that gave good results. Note that for fMRI recordings one needs to use bipolar montage with electrodes separated by 4 cm, else we found that the gradient artifact is too large.

Vertically: set a point 2 cm above navel, divide the distance between this point and the xiphoid complex in 3.
Horizontally: A landmark is the mid-clavicle line, to determine how far electrodes should be placed laterally. In practice, in some participants the mid-clavicle line is too lateral, and some electrodes would be placed on the ribs, rather than on the abdominal cavity. In such cases we use the coastal margin as the lateral border. If an electrode is placed on the ribs, respiration will be the dominant rhythm. This is not necessarily a big issue, since respiration falls in a different frequency range.

The location of the ground electrode does not seem to be critical: in different experiments we have used a ground on the back (left), or laterally on the left abdomen well below navel.

ELECTRODE PLACEMENT



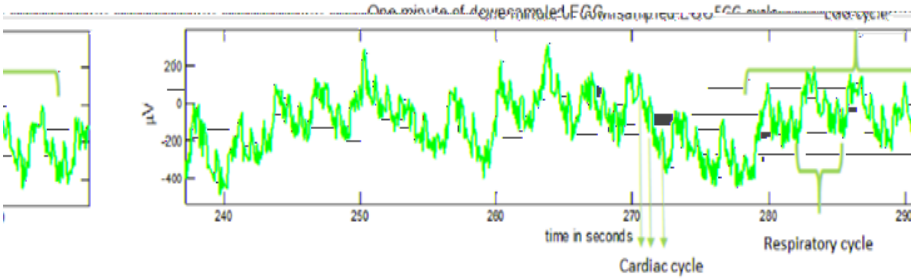
- **AMPLIFIER**
  - Given the very low oscillation frequency of the stomach (~0.05 Hertz), no high-pass filter should be applied at acquisition (DC mode of the amplifier).

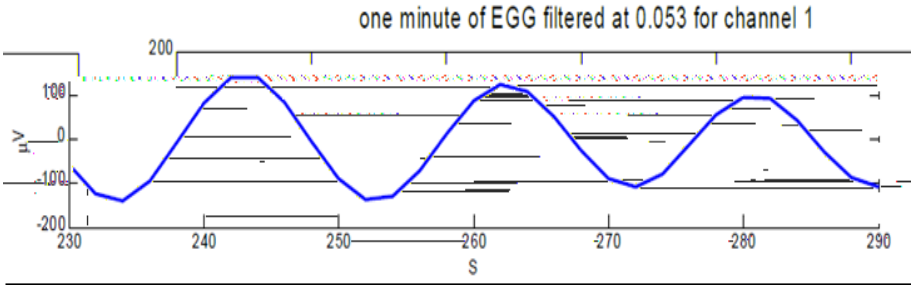
- **EXTRA-LONG RECORDINGS**
  - Given the very low oscillation frequency of the stomach (~0.05 Hertz), recordings need to be quite long, in one block. In practice we record at least 14 minutes, including some time before and after the period of interest to avoid windowing effects. In other words, get at least 30s of clean data before beginning any task, and record for an additional 30s at the end.
  - Still because of the very low frequency of the filters used, any artifact (subject moving or coughing) impacts the data for quite a long time. It is thus important to minimize movement artifact, they result in huge data loss.

3. ANALYSIS

- The power spectrum of EGG signal can be extracted using the Welch method; the first step is to determine which electrode shows the clearest peak in the normal EGG range (2-4 cpm, i.e. 0.0333 to 0.0666 Hz).
- An example of raw and filtered EGG data is shown below (this is of course a good data set where all rhythms can be identified in raw data)
- An example of fieldtrip script and a plot of the result are also shown.

RAW AND FILTERED EGG DATA





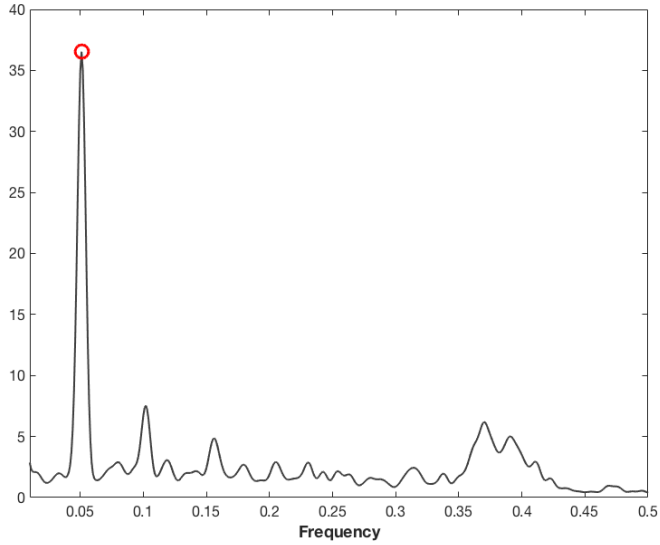
FIELD TRIP SCRIPT

```
cfg                         = [];
cfg.continuous              = 'yes';
cfg.dataset = 'EGG1.ncs';
dataft = ft_preprocessing(cfg);

cfg = [];
cfg.length                  = 200;
cfg.overlap                 = 0.75;
data_cut                    = ft_redefinetrial(cfg,dataft);

cfg                 = [];
cfg.output          = 'pow';
cfg.channel         = 'all';
cfg.method          = 'mtmfft';
cfg.taper           = 'hann';
cfg.keeptrials      = 'no';
cfg.foilim          = [0 5];
cfg.pad             = 1000;
FFT_EGG             = ft_freqanalysis(cfg, data_cut);
```

POWER SPECTRUM



The peak corresponding to EGG basal rhythm is shown in red.

- There might be a few artifacts