# Metarate example

This script provides examples of how the functions in this repository can be used to:

- calculate rate measures using the proportional duration summation method
- conduct a scalographic analysis
- plot a scalogram and a difference of scalograms

The workflow used to conduct analyses for the paper "Parameters of unit-based measures of speech rate" is documented in `metarate_workflow.mlx`.

Two inputs are necessary:

- A table of utterance-based segmentations, with segmentation information described below. Here we use `metarate_segmentdata_example.mat`, which contains segmented utterances from a single speaker (F01) from the HPRC corpus and can be found in the `examples` subdirectory of this repository.
- A table of target variables, with duration and location information described below. Here we use `data_pb_example.mat`, which contains the durations of /p/ and /b/ segments from the speaker.

Add all sub-directories of the respository to the path:

```
addpath(genpath('.'));
```

### Utterance segmentation

A unit-based segmentation of utterances is needed.

```
load('metarate_segmentdata_example.mat','TR');
```

Each utterance is associated with arrays of unit labels, such as phones and words:

```
list_of_phones = TR.phones{1}
```

```
list_of_phones = 1×29 cell
'sp'         'DH'         'AH0'        'B'          'ER1'        'CH'         'K⋯
```

```
list_of_words = TR.words{1}
```

```
list_of_words = 1×10 cell
'sp'         'THE'        'BIRCH'      'CANOE'      'SLID'       'ON'         'T⋯
```

The start and end times of each unit (here relative to the beginning of the recording) must be included as well, e.g.:

```
vector_of_phone_start_times = TR.phones_t0{1}
```

```
vector_of_phone_start_times = 1×29
         0    0.2000    0.2499    0.2898    0.3596    0.4594    0.5293    0.5991⋯
```

```
vector_of_phone_end_times = TR.phones_t1{1}
```

```
vector_of_phone_end_times = 1×29
    0.2000    0.2499    0.2898    0.3596    0.4594    0.5293    0.5991    0.6290 ⋯
```

In addition, maps between units at different levels must be included (but only if the rate measure unit is different from the target variable unit):

```
%the integer indices of words for each phone:
indices_of_words_byphone = TR.phones_word_ix{1}
```

```
indices_of_words_byphone = 1×29
     1     2     2     3     3     3     4     4     4     4     5     5     5 ⋯
```

```
%the integer indices of phones for each word:
indices_of_phones_byword = TR.words_phone_ix{1}
```

```
indices_of_phones_byword = 1×10 cell
```

⋯

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | [2,3] | [4,5,6] | [7,8,9,10] | [11,12,13... | [15,16] | [17,18] | [19,20,21... |

### Target variables

A table of target variables is needed.

```
load('data_pb_example.mat','D');
```

This table contains the duration of each phone, along with its start and end times, its midpoint, and its index (in the utterance):

```
info_target_phone = head(D(:,{'phone' 'dur' 't0' 't1' 'tmid' 'ix'}))
```

```
info_target_phone = 8×6 table
```

| | phone | dur | t0 | t1 | tmid | ix |
|---|---|---|---|---|---|---|
| 1 | 'B' | 0.0698 | 0.2898 | 0.3596 | 0.3247 | 4 |
| 2 | 'P' | 0.0898 | 1.4372 | 1.5270 | 1.4821 | 23 |
| 3 | 'B' | 0.0998 | 0.2698 | 0.3696 | 0.3197 | 4 |
| 4 | 'P' | 0.0898 | 1.9161 | 2.0059 | 1.9610 | 23 |
| 5 | 'B' | 0.0798 | 0.2798 | 0.3596 | 0.3197 | 4 |
| 6 | 'P' | 0.0898 | 1.9760 | 2.0658 | 2.0209 | 24 |
| 7 | 'B' | 0.0299 | 1.0580 | 1.0880 | 1.0730 | 18 |
| 8 | 'B' | 0.0599 | 1.1977 | 1.2576 | 1.2277 | 21 |

The table also contains information about the higher-level units that contain the phones:

```
info_word_contains_target_phone = head(D(:,{'word' 'word_t0' 'word_t1'}))
```

```
info_word_contains_target_phone = 8×3 table
```

| | word | word_t0 | word_t1 |
|---|---|---|---|
| 1 | 'BIRCH' | 0.2898 | 0.5293 |
| 2 | 'PLANKS' | 1.4372 | 1.8762 |
| 3 | 'BIRCH' | 0.2698 | 0.6190 |
| 4 | 'PLANKS' | 1.9161 | 2.4050 |
| 5 | 'BIRCH' | 0.2798 | 0.5991 |
| 6 | 'PLANKS' | 1.9760 | 2.4549 |
| 7 | 'BLUE' | 1.0580 | 1.1977 |
| 8 | 'BACKGROUND' | 1.1977 | 1.6667 |

### Proportional unit count timeseries

Use the function `metarate_calc_prop_durs` to calculate the timeseries of proportional counts for a given type of unit, and add these to the utterances table:

```
unit = 'words';
dt = 0.001;

for i=1:height(TR)

    %calculates frame time-points, proportional counts, and indices
    [frpnts,prop_dur,UIX] = metarate_calc_prop_durs(TR(i,:),unit,dt);

    %add the outputs to the table:
    TR.frt{i} = frpnts;
    TR.([unit '_ufr_prop_dur']){i} = prop_dur;
    TR.([unit '_ufr_map']){i} = uint8(UIX);     %max of 256 different units in utterance
end
```

### Scalographic analysis

```
% data selection strategy:
% bywindow, bytarget, beginanchored, endanchored
% use 'bytarget' to specify the across-window data selection strategy
datasel = 'bytarget';

% rate ratio:
% 0: proper rate, 1: inverse rate, 2: both
invrate = 2;

T = metarate_scalographic_analysis(TR,D,...
    'unit',unit,...
    'target_exclusion',true,...
    'data_selection',datasel,...
    'inverse_rate',invrate);
```

The output of `metarate_scalographic_analysis` is a table that contains various information about each analysis.

Included in the output is the partial correlation (rho), the p-value of the partial correlation, the rate measure used, the target variable name, the data selection strategy, the target exclusion parameter, the ratio expression (1 for inverse, 0 for proper), the number of tokens in the analysis, the number for which the rate measure was non-finite, the number for which an NaN value was observed, and the total number of valid tokens in the analysis:

```
head(T(:,{'rho' 'pval' 'rate_measure' 'target' 'scale' 'center'}))
```

ans = 8×6 table

| | rho | pval | rate_measure | target | scale | center |
|---|---|---|---|---|---|---|
| 1 | -0.1467 | 0.0001 | 'words' | 'phone' | 0.0500 | -0.4750 |
| 2 | -0.0975 | 0.0072 | 'words' | 'phone' | 0.0500 | -0.4500 |
| 3 | -0.1104 | 0.0023 | 'words' | 'phone' | 0.1000 | -0.4500 |
| 4 | -0.0435 | 0.2310 | 'words' | 'phone' | 0.0500 | -0.4250 |
| 5 | -0.1006 | 0.0055 | 'words' | 'phone' | 0.1000 | -0.4250 |
| 6 | -0.1473 | 0 | 'words' | 'phone' | 0.1500 | -0.4250 |
| 7 | -0.0776 | 0.0326 | 'words' | 'phone' | 0.0500 | -0.4000 |
| 8 | -0.1145 | 0.0016 | 'words' | 'phone' | 0.1000 | -0.4000 |

```
head(T(:,{'data_selection' 'target_exclusion' 'inverse_rate'}))
```

ans = 8×3 table

| | data_selection | target_exclusion | inverse_rate |
|---|---|---|---|
| 1 | 'bytarget' | 1 | 0 |
| 2 | 'bytarget' | 1 | 0 |
| 3 | 'bytarget' | 1 | 0 |
| 4 | 'bytarget' | 1 | 0 |
| 5 | 'bytarget' | 1 | 0 |
| 6 | 'bytarget' | 1 | 0 |
| 7 | 'bytarget' | 1 | 0 |
| 8 | 'bytarget' | 1 | 0 |

```
head(T(:,{'N_tokens' 'N_inf' 'N_nan' 'N_valid'}))
```

ans = 8×4 table

| | N_tokens | N_inf | N_nan | N_valid |
|---|---|---|---|---|
| 1 | 762 | 3 | 0 | 759 |
| 2 | 762 | 1 | 0 | 761 |

| | N_tokens | N_inf | N_nan | N_valid |
|---|---|---|---|---|
| 3 | 762 | 0 | 0 | 762 |
| 4 | 762 | 2 | 0 | 760 |
| 5 | 762 | 0 | 0 | 762 |
| 6 | 762 | 0 | 0 | 762 |
| 7 | 762 | 2 | 0 | 760 |
| 8 | 762 | 1 | 0 | 761 |

### Plotting scalograms

First prepare the scalographic information for plotting:

```
target_name = {'phone'};
rate_unit = {'words'};
inversion = 0;
exclusion = true;
datasel = {'bytarget'};

scvals = {{target_name rate_unit inversion exclusion datasel}};
G = prep_subsets(scvals);
G(1).subset
```

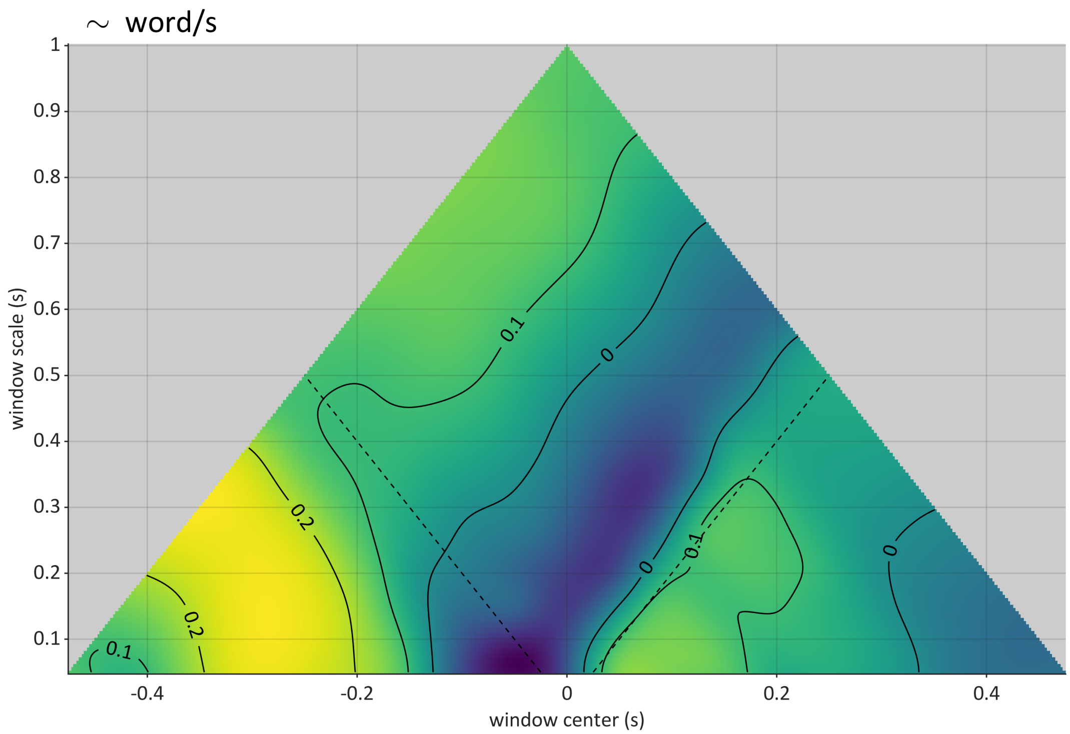
```
ans = struct with fields:
              target: {'phone'}
           rate_meas: {'words'}
        inverse_rate: 0
    target_exclusion: 1
      data_selection: {'bytarget'}
```

The function `prep_scalographs` generates a structure (with one element for each scalograph) with the centers (XX), scales (YY), and scalogram values (ZZ).

```
SC = prep_scalographs(T,G)
```

```
SC = struct with fields:
            XX: [951×1 double]
            YY: [191×1 double]
        varlab: '{\it{r}}^{\prime}'
            ZZ: [191×951 double]
     rho_range: [-0.2387 0.2545]
         clims: [-0.2397 0.2555]
          cmap: [5001×3 double]
    rho_levels: [0 0.1000 0.2000 0.3000 0.4000 0.5000 0.6000 0.7000 0.8000 0.9000 1]
        panlab: ' \sim  word/s'
         ax_ix: 1
```

```
ax = stf([1 1],[0.10 0.15 0.01 0.10]); %makes a figure with one axis
handles = plot_scalographs(SC,ax);
```




### Plotting a difference scalogram

First, let's conduct separate scalographic analyses on the /p/ and /b/ phones from our example dataset:

```
% make separate data tables
D_p = D(ismember(D.phone,{'P'}),:);
D_b = D(ismember(D.phone,{'B'}),:);

%conduct scalographic analyses
T_p = metarate_scalographic_analysis(TR,D_p,...
    'unit','words',...
    'target_exclusion',true,...
    'data_selection','bytarget',...
    'inverse_rate',0);

T_b = metarate_scalographic_analysis(TR,D_b,...
    'unit','words',...
    'target_exclusion',true,...
    'data_selection','bytarget',...
    'inverse_rate',0);

%rename target fields and combine:
T_p.target = repmat({'phone_p'},height(T_p),1);
T_b.target = repmat({'phone_b'},height(T_b),1);

T = [T_p; T_b];
```

Now let's prepare all three scalograms and plot:

```
scvals{1} = {{'phone_p'} {'words'} 0 1 {'bytarget'}};
scvals{2} = {{'phone_b'} {'words'} 0 1 {'bytarget'}};
scvals{3} = {{'phone_p'} {'words'} 0 1 {'bytarget'};
             {'phone_b'} {'words'} 0 1 {'bytarget'}}; %note that we have two rows here

G = prep_subsets(scvals);
SC = prep_scalographs(T,G);

ax = stf([1 2; nan 3],[0.05 0.10 0.01 0.05],[0.05 0.10]); %creates a figure with some axes
handles = plot_scalographs(SC,ax);
handles.th(1).String = ['p dur. ' handles.th(1).String];
handles.th(2).String = ['p dur. ' handles.th(2).String];
handles.th(3).String = ['p - b'];
```