This supplementary information presents :

- first, the code to generate the figures from the paper,
- second, some control experiments that were mentionned in the paper,
- finally, some perspectives for future work inspired by the algorithms presented in the paper.

Figures for "An adaptive algorithm for unsupervised learning"

In [1]:
```
%load_ext autoreload
%autoreload 2
```

In [2]:
```
import numpy as np
np.set_printoptions(precision=2, suppress=True)
seed = 42
np.random.seed(seed)
```

In [3]:
```
# some overhead for the formatting of figures
import matplotlib.pyplot as plt

fontsize = 12
FORMATS = ['.pdf', '.eps', '.png', '.tiff']
FORMATS = ['.pdf', '.png']
dpi_export = 600

fig_width_pt = 318.670  # Get this from LaTeX using \showthe\column
width
fig_width_pt = 450  # Get this from LaTeX using \showthe\columnwidt
h
#fig_width_pt = 1024 #221     # Get this from LaTeX using \showthe\
columnwidth / x264 asks for a multiple of 2
ppi = 72.27 # (constant) definition of the ppi = points per inch
inches_per_pt = 1.0/ppi  # Convert pt to inches
#inches_per_cm = 1./2.54
fig_width = fig_width_pt*inches_per_pt  # width in inches
grid_fig_width = 2*fig_width
phi = (np.sqrt(5) + 1. ) /2
#legend.fontsize = 8
#fig_width = 9
fig_height = fig_width/phi
figsize = (fig_width, fig_height)


def adjust_spines(ax, spines):
    for loc, spine in ax.spines.items():
        if loc in spines:
            spine.set_position(('outward', 10))  # outward by 10 po
ints
            spine.set_smart_bounds(True)
        else:
```

```
            spine.set_color('none')  # don't draw spine

    # turn off ticks where there is no spine
    if 'left' in spines:
        ax.yaxis.set_ticks_position('left')
    else:
        # no yaxis ticks
        ax.yaxis.set_ticks([])

    if 'bottom' in spines:
        ax.xaxis.set_ticks_position('bottom')
    else:
        # no xaxis ticks
        ax.xaxis.set_ticks([])

import matplotlib
pylab_defaults = {
    'font.size': 10,
    'xtick.labelsize':'medium',
    'ytick.labelsize':'medium',
    'text.usetex': False,
#    'font.family' : 'sans-serif',
#    'font.sans-serif' : ['Helvetica'],
    }

#matplotlib.rcParams.update({'font.size': 18, 'font.family': 'STIXG
eneral', 'mathtext.fontset': 'stix'})
matplotlib.rcParams.update(pylab_defaults)
#matplotlib.rcParams.update({'text.usetex': True})

import matplotlib.cm as cm


from IPython.display import Image

DEBUG = True
DEBUG = False
hl, hs = 10*'-', 10*' '
```

In [4]:
```
tag = 'ICLR'
datapath = '../../SparseHebbianLearning/database'
# different runs
opts = dict(datapath=datapath, verbose=0)
#opts = dict(cache_dir='cache_dir_cluster', datapath=datapath, verb
ose=0)
#opts = dict(cache_dir='cache_dir_ICLR', datapath=datapath, verbose
=0)
```

In [5]:
```
from shl_scripts.shl_experiments import SHL
shl = SHL(**opts)
data = shl.get_data(matname=tag)
```

In [6]:
```
shl?
```

```
Type:        SHL
String form: <shl_scripts.shl_experiments.SHL object at 0x10bb0640
0>
File:
~/science/SparseHebbianLearning/shl_scripts/shl_experiments.py
Docstring:
Base class to define SHL experiments:
    - initialization
    - coding and learning
    - visualization
    - quantitative analysis
```

In [7]:
```
print('number of patches, size of patches = ', data.shape)
print('average of patches = ', data.mean(), ' +/- ', data.mean(axis
=1).std())
SE = np.sqrt(np.mean(data**2, axis=1))
print('average energy of data = ', SE.mean(), '+/-', SE.std())
```

```
number of patches, size of patches =  (65520, 324)
average of patches =  -3.981519488962365e-05  +/-  0.0073902087809
88323
average energy of data =  0.2483654920811686 +/- 0.076717536535440
79
```

In [8]:
```
#!ls -l {shl.cache_dir}/{tag}*
!ls {shl.cache_dir}/{tag}*lock*
!rm {shl.cache_dir}/{tag}*lock*
#!rm {shl.cache_dir}/{tag}*
#!ls -l {shl.cache_dir}/{tag}*
```

```
cache_dir/ICLR_None_eta=0.00030_dico.pkl_lock
cache_dir/ICLR_None_eta=0.00030_dico.pkl_lock_pid-56154_host-ekla
```

figure 1: Role of homeostasis in learning sparse representations

TODO : cross-validate with 10 different learnings

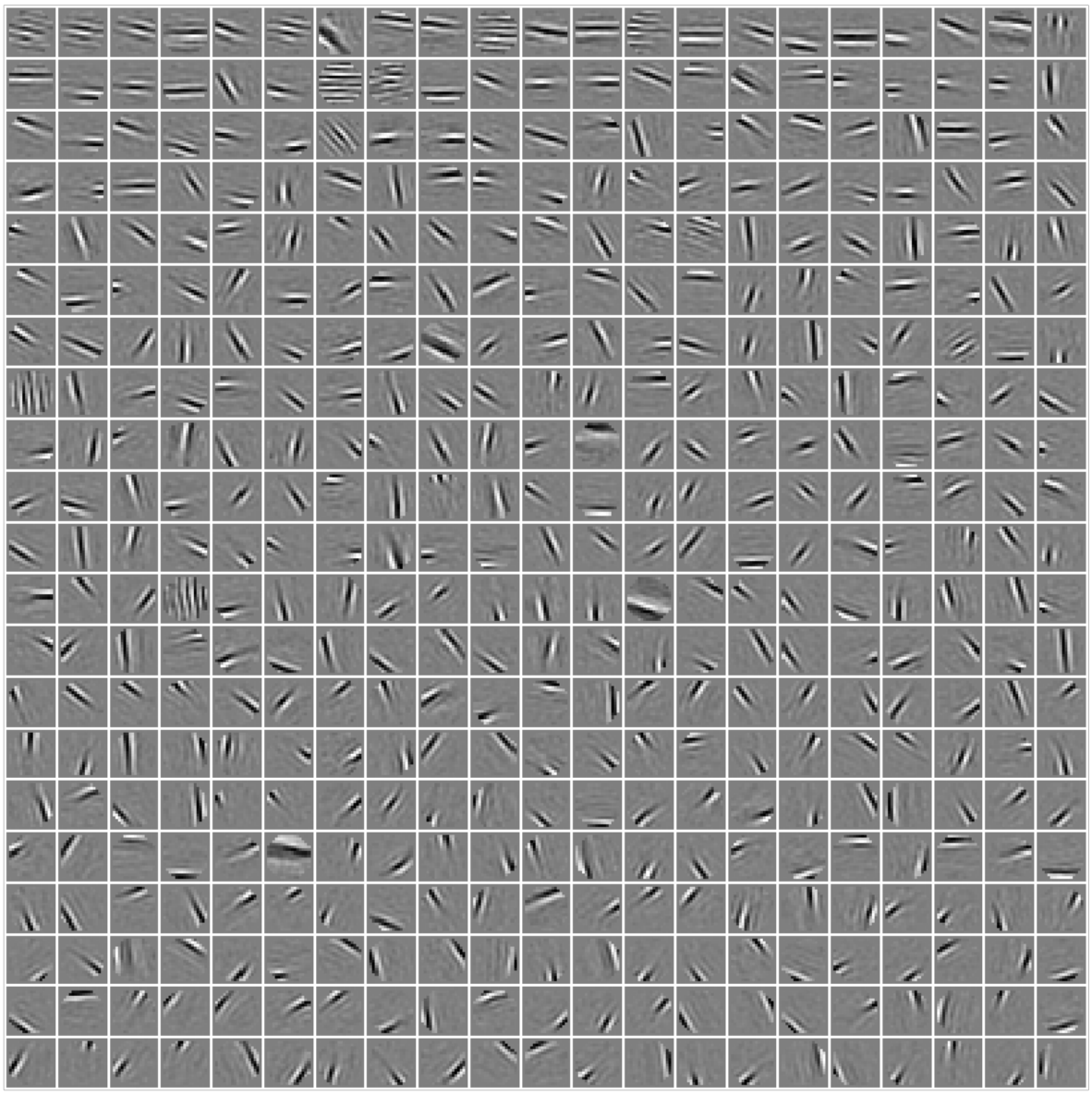
In [9]:
```
fname = 'figure_map'
N_cv = 10
one_cv = 0 # picking one to display intermediate results
```

learning

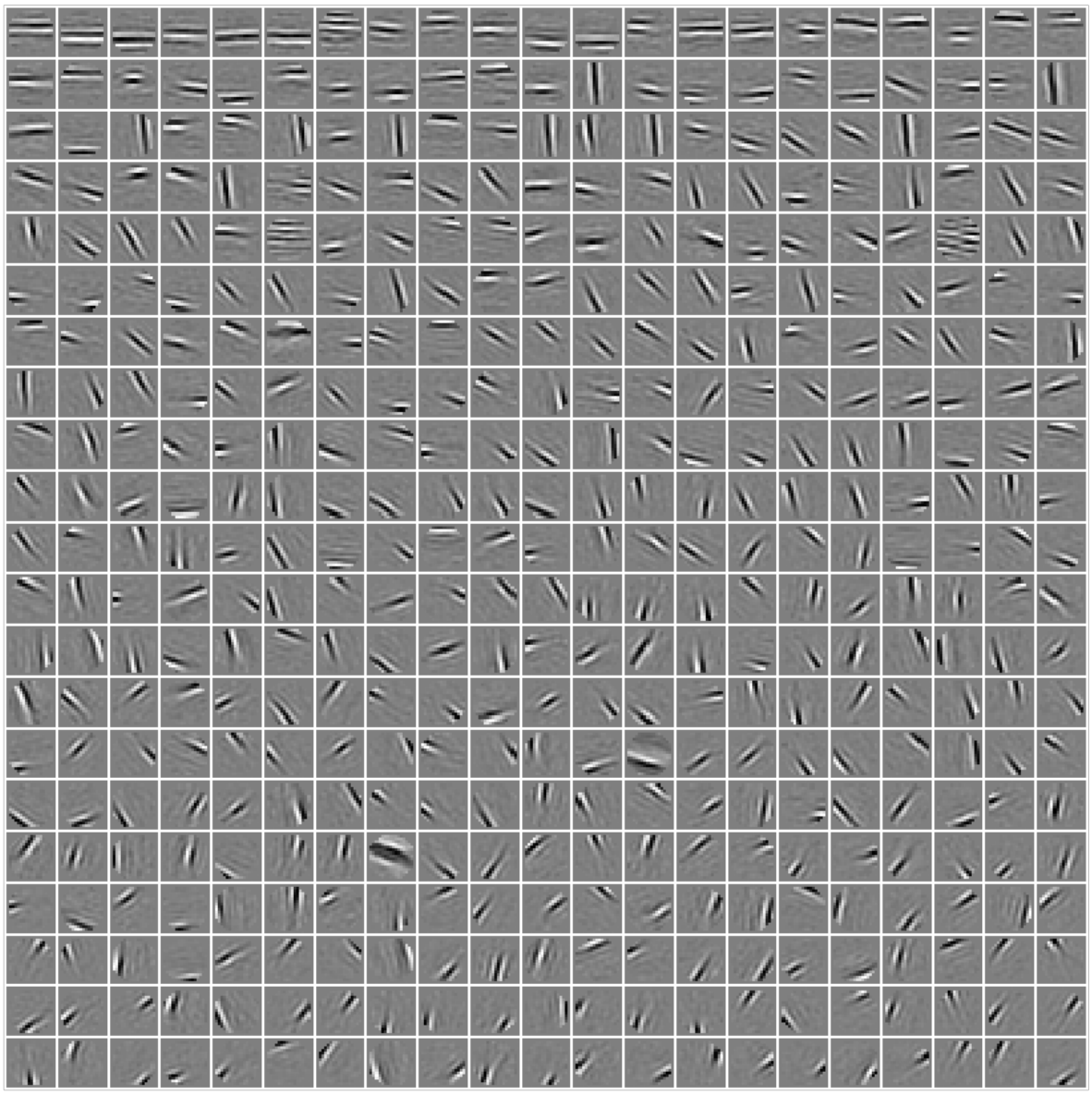
The actual learning is done in a second object (here `dico`) from which we can access another set of properties and functions (see the [shl_learn.py](https://github.com/bicv/SHL_scripts/blob/master/shl_scripts/shl_learn.py) script):

In [10]:
```
homeo_methods = ['None', 'OLS', 'HEH']

list_figures = ['show_dico', 'time_plot_error', 'time_plot_logL', '
time_plot_MC', 'show_Pcum']
list_figures = []
dico = {}
for i_cv in range(N_cv):
    dico[i_cv] = {}
    for homeo_method in homeo_methods:
        shl = SHL(homeo_method=homeo_method, seed=seed+i_cv, **opts
)
        dico[i_cv][homeo_method] = shl.learn_dico(data=data, list_f
igures=list_figures, matname=tag + '_' + homeo_method + '_seed=' +
str(seed+i_cv))

list_figures = ['show_dico']
for i_cv in [one_cv]:
    for homeo_method in homeo_methods:
        print(hl + hs + homeo_method[:3] + hs + hl)
        shl = SHL(homeo_method=homeo_method, seed=seed+i_cv, **opts
)
        shl.learn_dico(data=data, list_figures=list_figures, matnam
e=tag + '_' + homeo_method + '_seed=' + str(seed+i_cv))

        print('size of dictionary = (number of filters, size of ima
gelets) = ', dico[i_cv][homeo_method].dictionary.shape)
        print('average of filters = ',  dico[i_cv][homeo_method].di
ctionary.mean(axis=1).mean(),
              '+/-',  dico[i_cv][homeo_method].dictionary.mean(axis
=1).std())
        SE = np.sqrt(np.sum(dico[i_cv][homeo_method].dictionary**2,
axis=1))
        print('average energy of filters = ', SE.mean(), '+/-', SE.
std())
        plt.show()
```

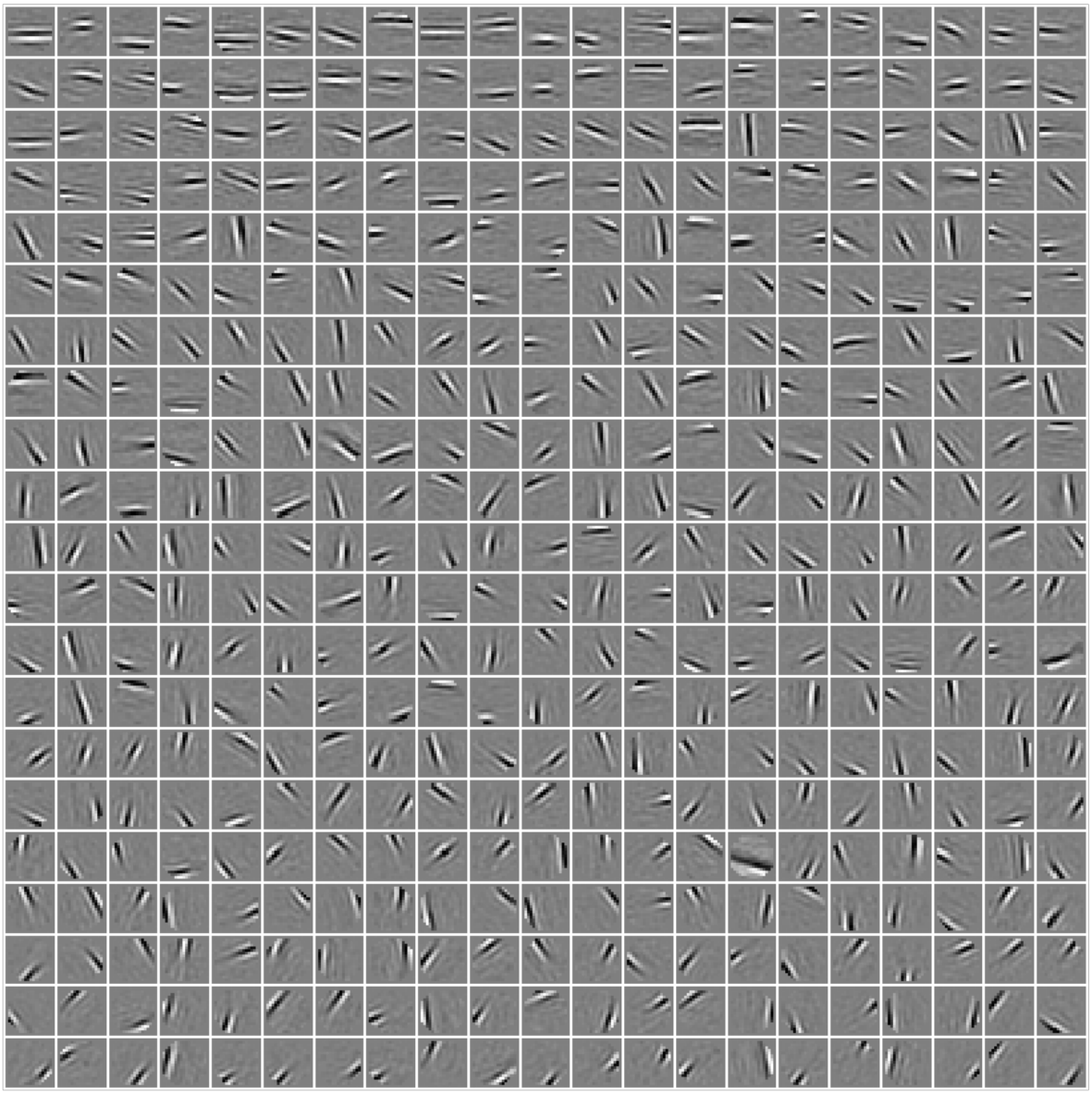
```
----------          Non          ----------
size of dictionary = (number of filters, size of imagelets) =  (44
1, 324)
average of filters =  7.123988737765042e-06 +/- 0.0011349341397207
146
average energy of filters =  1.0 +/- 3.546477361781819e-17
```



```
----------           OLS           ----------
size of dictionary = (number of filters, size of imagelets) =  (44
1, 324)
average of filters =  -3.1258426798939783e-07 +/- 0.00111271986956
86763
average energy of filters =  1.0 +/- 3.8488312480383476e-17
```



```
----------           HEH           ----------
size of dictionary = (number of filters, size of imagelets) =  (44
1, 324)
average of filters =  2.9233139706507077e-06 +/- 0.001106392181845
6044
average energy of filters =  1.0 +/- 4.06084993561207e-17
```



panel A: plotting some dictionaries

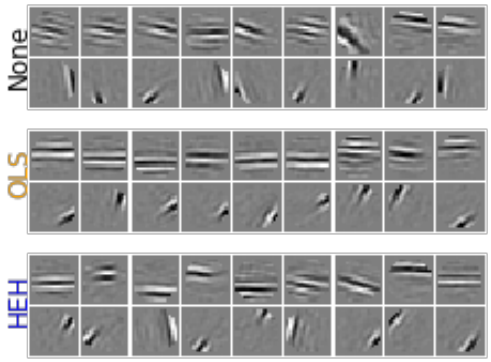
In [11]:
```
pname = '/tmp/panel_A' #pname = fname + '_A'
```

In [12]:
```
from shl_scripts import show_dico
if DEBUG: show_dico(shl, dico[one_cvi_cv][homeo_method], data=data,
dim_graph=(2,5))
```

In [13]:
```
dim_graph = (2, 9)
colors = ['black', 'orange', 'blue']
homeo_methods
```

Out[13]:
```
['None', 'OLS', 'HEH']
```

In [14]:
```
subplotpars = dict( left=0.042, right=1., bottom=0., top=1., wspace
=0.05, hspace=0.05,)
fig, axs = plt.subplots(3, 1, figsize=(fig_width/2, fig_width/(1+ph
i)), gridspec_kw=subplotpars)

for ax, color, homeo_method in zip(axs.ravel(), colors, homeo_metho
ds):
    ax.axis(c=color, lw=2, axisbg='w')
    ax.set_facecolor('w')
    fig, ax = show_dico(shl, dico[one_cv][homeo_method], data=data,
dim_graph=dim_graph, fig=fig, ax=ax)
    # ax.set_ylabel(homeo_method)
    ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color=co
lor, rotation=90)#, backgroundcolor='white'

for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
```



In [15]:
```
### TODO put the p_min an p_max value in the filter map
```

In [16]:
```
if DEBUG: Image(pname +'.png')
```

In [17]:
```
if DEBUG: help(fig.subplots_adjust)
```

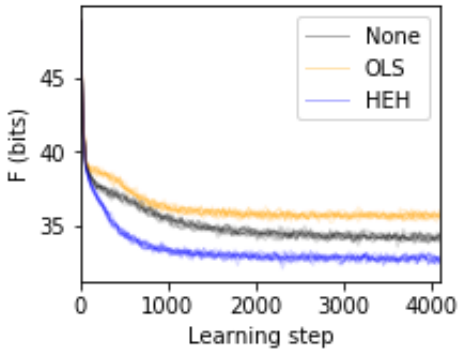
In [18]:
```
if DEBUG: help(plt.subplots)
```

In [19]:
```
if DEBUG: help(matplotlib.gridspec.GridSpec)
```

panel B: quantitative comparison

In [20]:
```
pname = '/tmp/panel_B' #fname + '_B'
```

In [21]:
```
from shl_scripts import time_plot
variable = 'F'
alpha_0, alpha = .3, .15
subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95)#, wspa
ce=0.05, hspace=0.05,)
fig, ax = plt.subplots(1, 1, figsize=(fig_width/2, fig_width/(1+phi
)), gridspec_kw=subplotpars)
for i_cv in range(N_cv):
    for color, homeo_method in zip(colors, homeo_methods):
        ax.axis(c='b', lw=2, axisbg='w')
        ax.set_facecolor('w')
        if i_cv==0:
            fig, ax = time_plot(shl, dico[i_cv][homeo_method], vari
able=variable, unit='bits', color=color, label=homeo_method, alpha=
alpha_0, fig=fig, ax=ax)
        else:
            fig, ax = time_plot(shl, dico[i_cv][homeo_method], vari
able=variable, unit='bits', color=color, alpha=alpha, fig=fig, ax=a
x)
        # ax.set_ylabel(homeo_method)
        #ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, col
or='k', rotation=90)#, backgroundcolor='white'
ax.legend(loc='best')
for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
if DEBUG: Image(pname +'.png')
```



Montage of the subplots

In [22]:
```
import tikzmagic
```

In [23]:
```
%load_ext tikzmagic
```

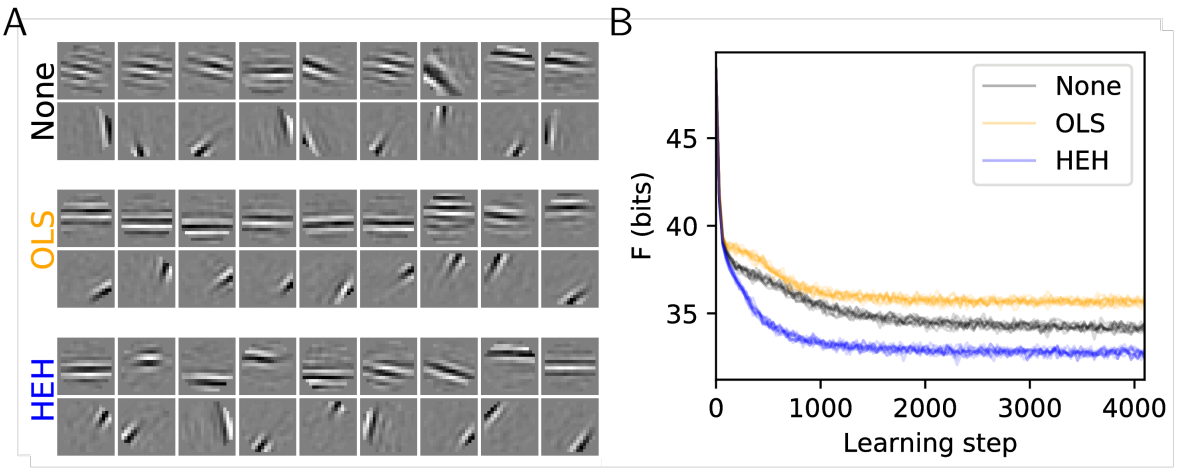
In [24]:
```
#DEBUG = True
if DEBUG: help(tikzmagic)
```

%tikz \draw (0,0) rectangle (1,1);%%tikz --save {fname}.pdf \draw[white, fill=white] (0.\linewidth,0) rectangle (1.\linewidth, .382\linewidth) ;

In [25]:
```
%%tikz -f pdf --save {fname}.pdf
\draw[white, fill=white] (0.\linewidth,0) rectangle (1.\linewidth,
.382\linewidth) ;
\draw [anchor=north west] (.0\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_A}};
\draw [anchor=north west] (.5\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_B}};
\begin{scope}[font=\bf\sffamily\large]
\draw [anchor=west,fill=white] (.0\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{A}$};
\draw [anchor=west,fill=white] (.53\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{B}$};
\end{scope}
```

In [26]:
```
!convert  -density {dpi_export} {fname}.pdf {fname}.jpg
!convert  -density {dpi_export} {fname}.pdf {fname}.png
#!convert  -density {dpi_export} -resize 5400  -units pixelsperinch
-flatten  -compress lzw  -depth 8 {fname}.pdf {fname}.tiff
Image(fname +'.png')
```

Out[26]:



!echo "width=" ; convert {fname}.tiff -format "%[fx:w]" info: !echo ", \nheight=" ; convert {fname}.tiff -format "%[fx:h]" info: !echo ", \nunit=" ; convert {fname}.tiff -format "%U" info:!identify {fname}.tiff

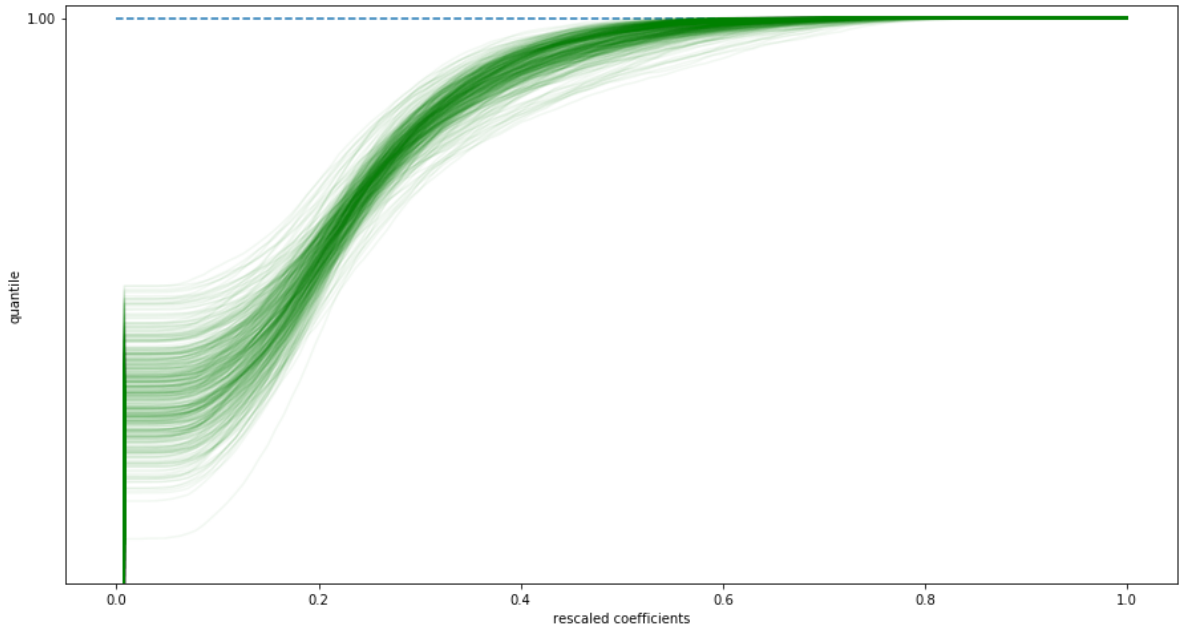
figure 2: Histogram Equalization Homeostasis

In [27]:
```
fname = 'figure_HEH'
```

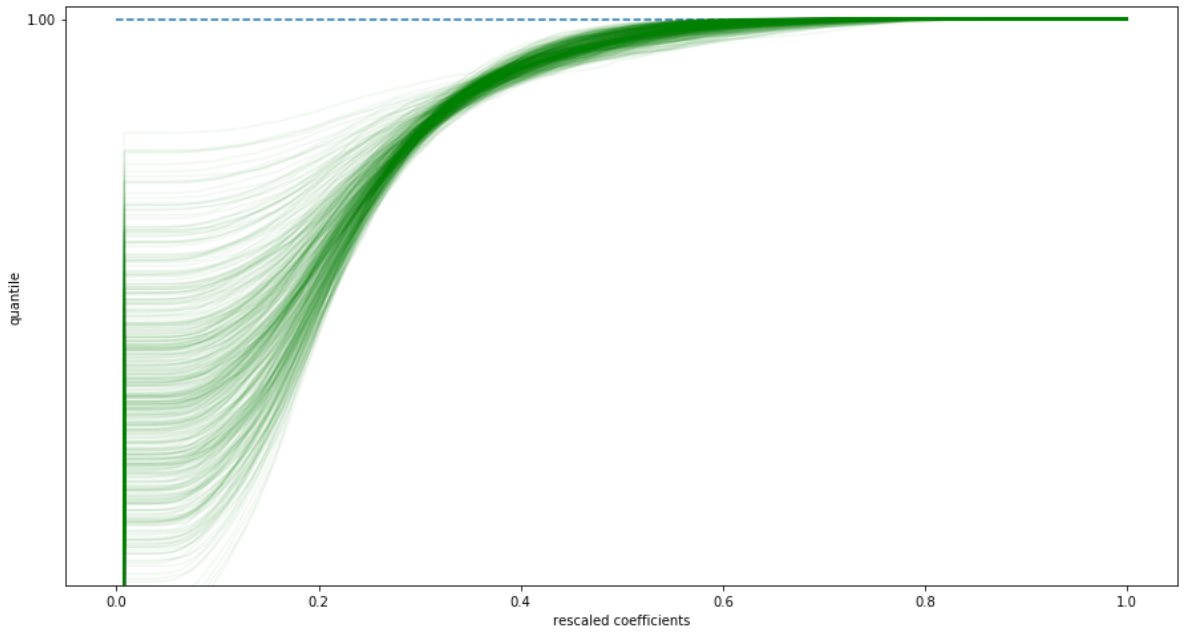
First collecting data:

In [28]:
```
list_figures = ['show_Pcum']

dico = {}
for homeo_method in homeo_methods:
    print(hl + hs + homeo_method + hs + hl)
    shl = SHL(homeo_method=homeo_method, **opts)
    #dico[homeo_method] = shl.learn_dico(data=data, list_figures=li
st_figures, matname=tag + '_' + homeo_method + '_' + str(one_cv))
    dico[homeo_method] = shl.learn_dico(data=data, list_figures=lis
t_figures, matname=tag + '_' + homeo_method + '_seed=' + str(seed+o
ne_cv))
    plt.show()
```

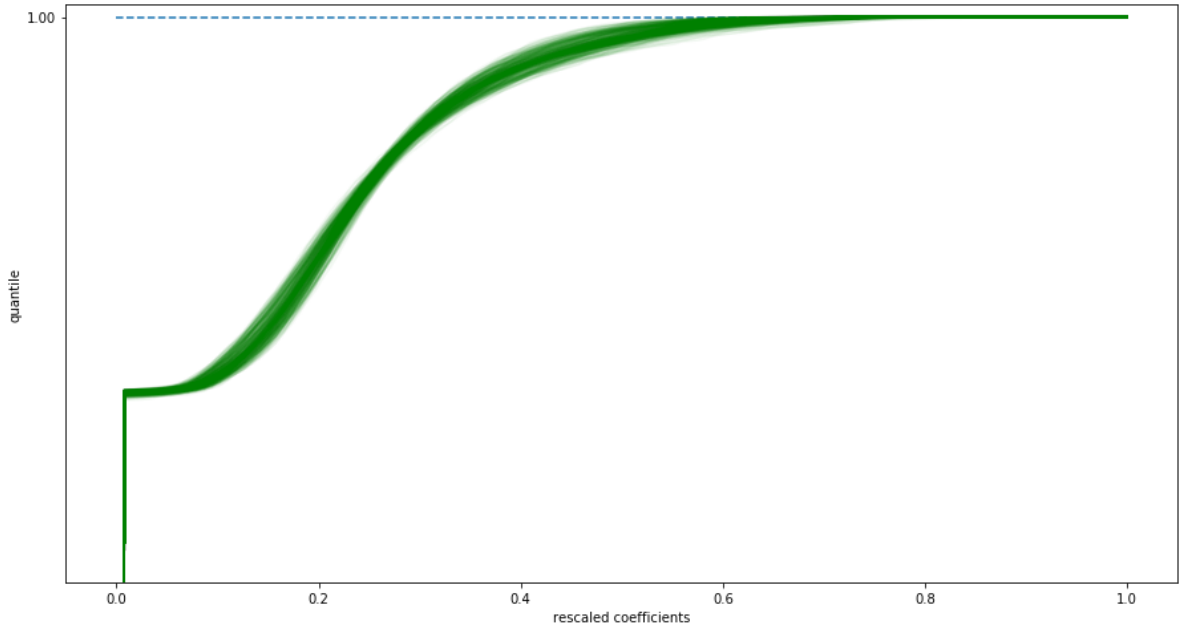
---------- None ----------



---------- OLS ----------



---------- HEH ----------

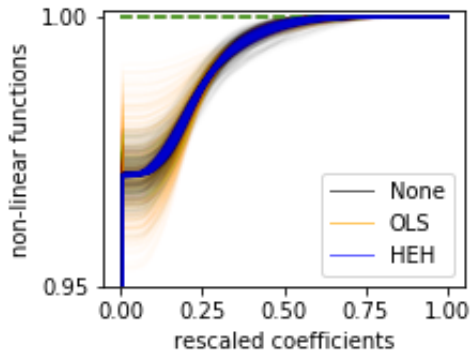


In [29]:
```
dico[homeo_method].P_cum.shape
```

Out[29]: (441, 128)

panel A: different P_cum

In [30]:
```
pname = '/tmp/panel_A' #pname = fname + '_A'

from shl_scripts import plot_P_cum
variable = 'F'
subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95)#, wspa
ce=0.05, hspace=0.05,)
fig, ax = plt.subplots(1, 1, figsize=(fig_width/2, fig_width/(1+phi
)), gridspec_kw=subplotpars)
for color, homeo_method in zip(colors, homeo_methods):
    ax.axis(c='b', lw=2, axisbg='w')
    ax.set_facecolor('w')
    fig, ax = plot_P_cum(dico[homeo_method].P_cum, ymin=0.95, ymax=
1.001,
                         title=None, suptitle=None, ylabel='non-lin
ear functions',
                         verbose=False, n_yticks=21, alpha=.02, c=c
olor, fig=fig, ax=ax)
    ax.plot([0], [0], lw=1, color=color, label=homeo_method, alpha=
.6)
    # ax.set_ylabel(homeo_method)
    #ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color='
k', rotation=90)#, backgroundcolor='white'
ax.legend(loc='lower right')
for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
if DEBUG: Image(pname +'.png')
```



In [31]:
```
if DEBUG: help(fig.legend)
```

panel B: comparing the effects of parameters

In [ ]:
```
pname = '/tmp/panel_B' #fname + '_B'


from shl_scripts.shl_experiments import SHL_set

homeo_methods = ['None', 'EMP', 'HAP', 'HEH', 'OLS']

homeo_methods = ['None', 'OLS', 'HEH']

variables = ['eta', 'alpha_homeo', 'eta_homeo', 'l0_sparseness', 'n
_dictionary']
variables = ['eta', 'alpha_homeo', 'eta_homeo', 'l0_sparseness']
```

```
variables = ['alpha_homeo', 'eta_homeo']
variables = ['eta', 'alpha_homeo', 'eta_homeo']
variables = ['eta', 'eta_homeo']

list_figures = []

bases = [10, 10, 2, 2]
bases = [4, 4, 4, 4]

for homeo_method, base in zip(homeo_methods, bases):
    opts_ = opts.copy()
    opts_.update(homeo_method=homeo_method)
    experiments = SHL_set(opts_, tag=tag + '_' + homeo_method, base
=base)
    experiments.run(variables=variables, n_jobs=1, verbose=0)


import matplotlib.pyplot as plt
subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95, wspace
=0.5, hspace=0.35,)

x, y = .05, -.3

if len(variables)==4:
    fig, axs = plt.subplots(2, 2, figsize=(fig_width/2, fig_width/(
1+phi)), gridspec_kw=subplotpars, sharey=True)
    for i_ax, variable in enumerate(variables):
        for color, homeo_method in zip(colors, homeo_methods):
            opts_ = opts.copy()
            opts_.update(homeo_method=homeo_method)
            experiments = SHL_set(opts_, tag=tag + '_' + homeo_meth
od)
            ax = axs[i_ax%2][i_ax//2]
            fig, ax = experiments.scan(variable=variable, list_figu
res=[], display='final', fig=fig, ax=ax, color=color, display_varia
ble='F', verbose=0) #, label=homeo_metho
            ax.set_xlabel('') #variable
            ax.text(x, y,  variable, transform=axs[i_ax].transAxes)
            #axs[i_ax].get_xaxis().set_major_formatter(matplotlib.t
icker.ScalarFormatter())

else:
    fig, axs = plt.subplots(len(variables), 1, figsize=(fig_width/2
, fig_width/(1+phi)), gridspec_kw=subplotpars, sharey=True)

    for i_ax, variable in enumerate(variables):
        for color, homeo_method in zip(colors, homeo_methods):
            opts_ = opts.copy()
            opts_.update(homeo_method=homeo_method)
            experiments = SHL_set(opts_, tag=tag + '_' + homeo_meth
od)
            fig, axs[i_ax] = experiments.scan(variable=variable, li
st_figures=[], display='final', fig=fig, ax=axs[i_ax], color=color,
display_variable='F', verbose=0) #, label=homeo_metho
            axs[i_ax].set_xlabel('') #variable
            axs[i_ax].text(x, y,  variable, transform=axs[i_ax].tra
nsAxes)
```

```
            #axs[i_ax].get_xaxis().set_major_formatter(matplotlib.t
icker.ScalarFormatter())

#fig.legend(loc='lower right')
for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
if DEBUG: Image(pname +'.png')
```

Montage of the subplots

In [ ]:
```
%%tikz -f pdf --save {fname}.pdf
\draw[white, fill=white] (0.\linewidth,0) rectangle (1.\linewidth,
.382\linewidth) ;
\draw [anchor=north west] (.0\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_A.pdf}};
\draw [anchor=north west] (.5\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_B.pdf}};
\begin{scope}[font=\bf\sffamily\large]
\draw [anchor=west,fill=white] (.0\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{A}$};
\draw [anchor=west,fill=white] (.53\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{B}$};
\end{scope}
```

In [ ]:
```
!convert  -density {dpi_export} {fname}.pdf {fname}.jpg
!convert  -density {dpi_export} {fname}.pdf {fname}.png
#!convert  -density {dpi_export} -resize 5400  -units pixelsperinch
-flatten  -compress lzw  -depth 8 {fname}.pdf {fname}.tiff
Image(fname +'.png')
```

!echo "width=" ; convert {fname}.tiff -format "%[fx:w]" info: !echo ", \nheight=" ; convert {fname}.tiff -format "%[fx:h]" info: !echo ", \nunit=" ; convert {fname}.tiff -format "%U" info:!identify {fname}.tiff

figure 3:

learning

In [ ]:
```
fname = 'figure_HAP'
```

In [ ]:
```
colors = ['orange', 'red', 'green', 'blue']
homeo_methods = ['OLS', 'HEH', 'EMP', 'HAP']
list_figures = []
dico = {}
for i_cv in range(N_cv):
    dico[i_cv] = {}
    for homeo_method in homeo_methods:
        shl = SHL(homeo_method=homeo_method, seed=seed+i_cv, **opts
)
        dico[i_cv][homeo_method] = shl.learn_dico(data=data, list_f
igures=list_figures, matname=tag + '_' + homeo_method + '_seed=' +
str(seed+i_cv))

list_figures = ['show_dico'] if DEBUG else []
for i_cv in [one_cv]:
    for homeo_method in homeo_methods:
        print(hl + hs + homeo_method + hs + hl)
        shl = SHL(homeo_method=homeo_method, seed=seed+i_cv, **opts
)
        shl.learn_dico(data=data, list_figures=list_figures, matnam
e=tag + '_' + homeo_method + '_seed=' + str(seed+i_cv))
        plt.show()
        print('size of dictionary = (number of filters, size of ima
gelets) = ', dico[i_cv][homeo_method].dictionary.shape)
        print('average of filters = ',  dico[i_cv][homeo_method].di
ctionary.mean(axis=1).mean(),
              '+/-',  dico[i_cv][homeo_method].dictionary.mean(axis
=1).std())
        SE = np.sqrt(np.sum(dico[i_cv][homeo_method].dictionary**2,
axis=1))
        print('average energy of filters = ', SE.mean(), '+/-', SE.
std())
```

panel A: plotting some dictionaries

In [ ]:
```
pname = '/tmp/panel_A' #pname = fname + '_A'
```

In [ ]:
```
subplotpars = dict( left=0.042, right=1., bottom=0., top=1., wspace
=0.05, hspace=0.05,)
fig, axs = plt.subplots(3, 1, figsize=(fig_width/2, fig_width/(1+ph
i)), gridspec_kw=subplotpars)

for ax, color, homeo_method in zip(axs.ravel(), colors[1:], homeo_m
ethods[1:]):
    ax.axis(c=color, lw=2, axisbg='w')
    ax.set_facecolor('w')
    from shl_scripts import show_dico
    fig, ax = show_dico(shl, dico[one_cv][homeo_method], data=data,
dim_graph=dim_graph, fig=fig, ax=ax)
    # ax.set_ylabel(homeo_method)
    ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color=co
lor, rotation=90)#, backgroundcolor='white'

for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
```

panel B: quantitative comparison

In [ ]:
```
pname = '/tmp/panel_B' #fname + '_B'
```

In [ ]:
```
from shl_scripts import time_plot
variable = 'F'
alpha = .3
subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95)#, wspa
ce=0.05, hspace=0.05,)
fig, ax = plt.subplots(1, 1, figsize=(fig_width/2, fig_width/(1+phi
)), gridspec_kw=subplotpars)
for i_cv in range(N_cv):
    for color, homeo_method in zip(colors, homeo_methods):
        ax.axis(c='b', lw=2, axisbg='w')
        ax.set_facecolor('w')
        if i_cv==0:
            fig, ax = time_plot(shl, dico[i_cv][homeo_method], vari
able=variable, unit='bits', color=color, label=homeo_method, alpha=
alpha_0, fig=fig, ax=ax)
        else:
            fig, ax = time_plot(shl, dico[i_cv][homeo_method], vari
able=variable, unit='bits', color=color, alpha=alpha, fig=fig, ax=a
x)
ax.legend(loc='best')
for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)
if DEBUG: Image(pname +'.png')
```

In [ ]:
```
if DEBUG: Image(pname +'.png')
```

Montage of the subplots

In [ ]:
```
%%tikz -f pdf --save {fname}.pdf
\draw[white, fill=white] (0.\linewidth,0) rectangle (1.\linewidth,
.382\linewidth) ;
\draw [anchor=north west] (.0\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_A}};
\draw [anchor=north west] (.5\linewidth, .382\linewidth) node {\inc
ludegraphics[width=.5\linewidth]{/tmp/panel_B}};
\begin{scope}[font=\bf\sffamily\large]
\draw [anchor=west,fill=white] (.0\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{A}$};
\draw [anchor=west,fill=white] (.53\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{B}$};
\end{scope}
```

In [ ]:
```
!convert  -density {dpi_export} {fname}.pdf {fname}.jpg
!convert  -density {dpi_export} {fname}.pdf {fname}.png
#!convert  -density {dpi_export} -resize 5400  -units pixelsperinch
-flatten  -compress lzw  -depth 8 {fname}.pdf {fname}.tiff
Image(fname +'.png')
```

!echo "width=" ; convert {fname}.tiff -format "%[fx:w]" info: !echo ", \nheight=" ; convert {fname}.tiff -format "%[fx:h]" info: !echo ", \nunit=" ; convert {fname}.tiff -format "%U" info:!identify {fname}.tiff

figure 4: Convolutional Neural Network

In [ ]:
```
fname = 'figure_CNN'
```

In [ ]:
```
from CHAMP.DataLoader import LoadData
from CHAMP.DataTools import LocalContrastNormalization, FilterInput
Data, GenerateMask
from CHAMP.Monitor import DisplayDico, DisplayConvergenceCHAMP, Dis
playWhere

import os
datapath = os.path.join("/tmp", "database")
path = os.path.join(datapath, "Raw_DataBase")
TrSet, TeSet = LoadData('Face', path, decorrelate=False, resize=(65
, 65))

# MP Parameters
nb_dico = 20
width = 9
dico_size = (width, width)
l0 = 20
seed = 42
# Learning Parameters
eta = .05
nb_epoch = 500

TrSet, TeSet = LoadData('Face', path, decorrelate=False, resize=(65
, 65))
N_TrSet, _, _, _ = LocalContrastNormalization(TrSet)
Filtered_L_TrSet = FilterInputData(
    N_TrSet, sigma=0.25, style='Custom', start_R=15)

mask = GenerateMask(full_size=(nb_dico, 1, width, width), sigma=0.8
, style='Gaussian')

from CHAMP.CHAMP_Layer import CHAMP_Layer

from CHAMP.DataTools import SaveNetwork, LoadNetwork
homeo_methods = ['None', 'HAP']

for homeo_method, eta_homeo  in zip(homeo_methods, [0., 0.0025]):
    ffname = 'cache_dir_CNN/CHAMP_low_' + homeo_method + '.pkl'
    try:
        L1_mask = LoadNetwork(loading_path=ffname)
    except:
        L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico,
                              dico_size=dico_size, mask=mask, verbose=1
)
        dico_mask = L1_mask.TrainLayer(
            Filtered_L_TrSet, eta=eta, eta_homeo=eta_homeo, nb_epoc
h=nb_epoch, seed=seed)
        SaveNetwork(Network=L1_mask, saving_path=ffname)
```

panel A: plotting some dictionaries

In [ ]:
```
pname = '/tmp/panel_A' #pname = fname + '_A'
```

subplotpars = dict(left=0.042, right=1., bottom=0., top=1., wspace=0.05, hspace=0.05,) fig, axs =

plt.subplots(2, 1, figsize=(fig_width/2, fig_width/(1+phi)), gridspec_kw=subplotpars) for ax, color, homeo_method in zip(axs.ravel(), ['black', 'green'], homeo_methods): ax.axis(c=color, lw=2, axisbg='w') ax.set_facecolor('w') ffname = 'cache_dir/CHAMP_low_' + homeo_method + '.pkl' L1_mask = LoadNetwork(loading_path=ffname) fig, ax = DisplayDico(L1_mask.dictionary, fig=fig, ax=ax) # ax.set_ylabel(homeo_method) ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color=color, rotation=90)#, backgroundcolor='white' for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export)

In [ ]:
```
subplotpars = dict(left=0.042, right=1., bottom=0., top=1., wspace=
0.05, hspace=0.05,)

for color, homeo_method in zip(['black', 'green'], homeo_methods):
    #fig, axs = plt.subplots(1, 1, figsize=(fig_width/2, fig_width/
(1+phi)), gridspec_kw=subplotpars)
    ffname = 'cache_dir_CNN/CHAMP_low_' + homeo_method + '.pkl'
    L1_mask = LoadNetwork(loading_path=ffname)
    fig, ax = DisplayDico(L1_mask.dictionary)
    # ax.set_ylabel(homeo_method)
    #for ax in list(axs):
    #    ax.axis(c=color, lw=2, axisbg='w')
    #    ax.set_facecolor('w')
    ax[0].text(-4, 3, homeo_method, fontsize=8, color=color, rotati
on=90)#, backgroundcolor='white'
    plt.tight_layout( pad=0., w_pad=0., h_pad=.0)


    for ext in FORMATS: fig.savefig(pname + '_' + homeo_method + ex
t, dpi=dpi_export)
```

panel B: quantitative comparison

In [ ]:
```
pname = '/tmp/panel_B' #fname + '_B'
```

from shl_scripts import time_plot variable = 'F' alpha = .3 subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95)#, wspace=0.05, hspace=0.05,) fig, axs = plt.subplots(2, 1, figsize=(fig_width/2, fig_width/(1+phi)), gridspec_kw=subplotpars) for ax, color, homeo_method in zip(axs, ['black', 'green'], homeo_methods): print(ax, axs) ffname = 'cache_dir_CNN/CHAMP_low_' + homeo_method + '.pkl' L1_mask = LoadNetwork(loading_path=ffname) fig, ax = DisplayConvergenceCHAMP(L1_mask, to_display=['histo'], fig=fig, ax=ax) ax.axis(c=color, lw=2, axisbg='w') ax.set_facecolor('w') # ax.set_ylabel(homeo_method) #ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color=color, rotation=90)#, backgroundcolor='white' for ext in FORMATS: fig.savefig(pname + ext, dpi=dpi_export) if DEBUG: Image(pname +'.png')

In [ ]:
```
from shl_scripts import time_plot
variable = 'F'
alpha = .3
subplotpars = dict(left=0.2, right=.95, bottom=0.2, top=.95)#, wspace=0.05, hspace=0.05,)

for color, homeo_method in zip(['black', 'green'], homeo_methods):
    #fig, axs = plt.subplots(1, 1, figsize=(fig_width/2, fig_width/(1+phi)), gridspec_kw=subplotpars)
    ffname = 'cache_dir_CNN/CHAMP_low_' + homeo_method + '.pkl'
    L1_mask = LoadNetwork(loading_path=ffname)
    fig, ax = DisplayConvergenceCHAMP(L1_mask, to_display=['histo'], color=color)
    ax.axis(c=color, lw=2, axisbg='w')
    ax.set_facecolor('w')
    ax.set_ylabel('counts')
    ax.set_xlabel('feature #')
    ax.set_ylim(0, 560)
    #ax.text(-8, 7*dim_graph[0], homeo_method, fontsize=12, color=color, rotation=90)#, backgroundcolor='white'
    #ax[0].text(-8, 3, homeo_method, fontsize=12, color=color, rotation=90)#, backgroundcolor='white'

    for ext in FORMATS: fig.savefig(pname + '_' + homeo_method + ext, dpi=dpi_export)
    if DEBUG: Image(pname +'.png')
```

Montage of the subplots

In [ ]:
```
%ls -ltr /tmp/panel_*
```

In [ ]:
```
fname
```

In [ ]:
```
382+191
```

In [ ]:
```
%%tikz -f pdf --save {fname}.pdf
\draw[white, fill=white] (0.\linewidth,0) rectangle (1.\linewidth,
.382\linewidth) ;
\draw [anchor=north west] (.0\linewidth, .375\linewidth) node {\inc
ludegraphics[width=.95\linewidth]{/tmp/panel_A_None}};
\draw [anchor=north west] (.0\linewidth, .300\linewidth) node {\inc
ludegraphics[width=.95\linewidth]{/tmp/panel_A_HAP}};
\draw [anchor=north west] (.0\linewidth, .191\linewidth) node {\inc
ludegraphics[width=.45\linewidth]{/tmp/panel_B_None}};
\draw [anchor=north west] (.5\linewidth, .191\linewidth) node {\inc
ludegraphics[width=.45\linewidth]{/tmp/panel_B_HAP}};
\begin{scope}[font=\bf\sffamily\large]
%\draw [anchor=west,fill=white] (.0\linewidth, .382\linewidth) node
[above right=-3mm] {$\mathsf{A}$};
\draw [anchor=west,fill=white] (.0\linewidth, .191\linewidth) node
[above right=-3mm] {$\mathsf{A}$};
\draw [anchor=west,fill=white] (.53\linewidth, .191\linewidth) node
[above right=-3mm] {$\mathsf{B}$};
\end{scope}
```

In [ ]:
```
!convert  -density {dpi_export} {fname}.pdf {fname}.jpg
!convert  -density {dpi_export} {fname}.pdf {fname}.png
#!convert  -density {dpi_export} -resize 5400  -units pixelsperinch
-flatten  -compress lzw  -depth 8 {fname}.pdf {fname}.tiff
Image(fname +'.png')
```

!echo "width=" ; convert {fname}.tiff -format "%[fx:w]" info: !echo ", \nheight=" ; convert {fname}.tiff -format "%[fx:h]" info: !echo ", \nunit=" ; convert {fname}.tiff -format "%U" info:!identify {fname}.tiff

coding

The learning itself is done via a gradient descent but is highly dependent on the coding / decoding algorithm. This belongs to a another function (in the shl_encode.py (https://github.com/bicv/SHL_scripts/blob/master/shl_scripts/shl_encode.py) script)

Supplementary controls

starting a learning

In [ ]:
```
shl = SHL(**opts)
list_figures = ['show_dico', 'show_Pcum', 'time_plot_F']
dico = shl.learn_dico(data=data, list_figures=list_figures, matname
=tag + '_vanilla')
```

In [ ]:
```
print('size of dictionary = (number of filters, size of imagelets)
= ', dico.dictionary.shape)
print('average of filters = ',  dico.dictionary.mean(axis=1).mean()
,
      '+/-',  dico.dictionary.mean(axis=1).std())
SE = np.sqrt(np.sum(dico.dictionary**2, axis=1))
print('average energy of filters = ', SE.mean(), '+/-', SE.std())
```

getting help

In [ ]:
```
help(shl)
```

In [ ]:
```
help(dico)
```

loading a database

Loading patches, with or without mask:

In [ ]:
```
N_patches = 12
from shl_scripts.shl_tools import show_data
opts_ = opts.copy()
opts_.update(verbose=0)
for i, (do_mask, label) in enumerate(zip([False, True], ['Without m
ask', 'With mask'])):
    data_ = SHL(DEBUG_DOWNSCALE=1, N_patches=N_patches, n_image=1,
do_mask=do_mask, seed=seed, **opts_).get_data()
    fig, axs = show_data(data_)
    axs[0].set_ylabel(label);
    plt.show()
```

Testing different algorithms

In [ ]:
```
fig, ax = None, None

for homeo_method in ['None', 'HAP']:
    for algorithm in ['lasso_lars', 'lars', 'elastic', 'omp', 'mp']
: # 'threshold', 'lasso_cd',
        opts_ = opts.copy()
        opts_.update(homeo_method=homeo_method, learning_algorithm=
algorithm, verbose=0)
        shl = SHL(**opts_)
        dico= shl.learn_dico(data=data, list_figures=[],
                             matname=tag + ' - algorithm={}'.format(algor
ithm) + ' - homeo_method={}'.format(homeo_method))
        fig, ax = shl.time_plot(dico, variable='F', fig=fig, ax=ax,
label=algorithm +'_' + homeo_method)

    ax.legend()
```

Testing two different dictionary initalization strategies

White Noise Initialization + Learning

In [ ]:
```
shl = SHL(one_over_F=False, **opts)
dico_w = shl.learn_dico(data=data, matname=tag + '_WHITE', list_fig
ures=[])
shl = SHL(one_over_F=True, **opts)
dico_1oF = shl.learn_dico(data=data, matname=tag + '_OVF', list_fig
ures=[])
fig_error, ax_error = None, None
fig_error, ax_error = shl.time_plot(dico_w, variable='F', fig=fig_e
rror, ax=ax_error, color='blue', label='white noise')
fig_error, ax_error = shl.time_plot(dico_1oF, variable='F', fig=fig
_error, ax=ax_error, color='red', label='one over f')
#ax_error.set_ylim((0, .65))
ax_error.legend(loc='best')
```

Testing two different learning rates strategies

We use by defaut the strategy of ADAM, see https://arxiv.org/pdf/1412.6980.pdf (https://arxiv.org/pdf/1412.6980.pdf)

In [ ]:
```
shl = SHL(beta1=0., **opts)
dico_fixed = shl.learn_dico(data=data, matname=tag + '_fixed', list
_figures=[])
shl = SHL(**opts)
dico_default = shl.learn_dico(data=data, matname=tag + '_default',
list_figures=[])
fig_error, ax_error = None, None
fig_error, ax_error = shl.time_plot(dico_fixed, variable='F', fig=f
ig_error, ax=ax_error, color='blue', label='fixed')
fig_error, ax_error = shl.time_plot(dico_default, variable='F', fig
=fig_error, ax=ax_error, color='red', label='ADAM')
#ax_error.set_ylim((0, .65))
ax_error.legend(loc='best')
```

Testing different number of neurons and sparsity

As suggested by AnonReviewer3, we have tested how the convergence was modified by changing the number of neurons. By comparing different numbers of neurons we could re-draw the same figures for the convergence of the algorithm as in our original figures. In addition, we have also checked that this result will hold on a range of sparsity levels. In particular, we found that in general, increasing the `l0_sparseness` parameter, the convergence took progressively longer. Importantly, we could see that in both cases, this did not depend on the kind of homeostasis heuristic chosen, proving the generality of our results.

This is shown in the supplementary material that we have added to our revision ("Testing different number of neurons and sparsity") . This useful extension proves the originality of our work as highlighted in point 4, and the generality of these results compared to the parameters of the network.

In [ ]:
```
from shl_scripts.shl_experiments import SHL_set
homeo_methods = ['None', 'OLS', 'HEH']
homeo_methods = ['None', 'EMP', 'HAP', 'HEH', 'OLS']

variables = ['l0_sparseness', 'n_dictionary']
list_figures = []

#n_dictionary=21**2

for homeo_method in homeo_methods:
    opts_ = opts.copy()
    opts_.update(homeo_method=homeo_method, datapath=datapath)
    experiments = SHL_set(opts_, tag=tag + '_' + homeo_method)
    experiments.run(variables=variables, n_jobs=1, verbose=0)

fig, axs = plt.subplots(len(variables), 1, figsize=(fig_width/2, fi
g_width/(1+phi)), gridspec_kw=subplotpars, sharey=True)

for i_ax, variable in enumerate(variables):
    for color, homeo_method in zip(colors, homeo_methods):
        opts_ = opts.copy()
        opts_.update(homeo_method=homeo_method, datapath=datapath)
        experiments = SHL_set(opts_, tag=tag + '_' + homeo_method)
        fig, axs[i_ax] = experiments.scan(variable=variable, list_f
igures=[], display='final', fig=fig, ax=axs[i_ax], color=color, dis
play_variable='F', verbose=0) #, label=homeo_metho
        axs[i_ax].set_xlabel('') #variable
        axs[i_ax].text(.1, .8,  variable, transform=axs[i_ax].trans
Axes)
        #axs[i_ax].get_xaxis().set_major_formatter(matplotlib.ticke
r.ScalarFormatter())
```

Perspectives

Convolutional neural networks

In [ ]:
```
from CHAMP.DataLoader import LoadData
from CHAMP.DataTools import LocalContrastNormalization, FilterInput
Data, GenerateMask
from CHAMP.Monitor import DisplayDico, DisplayConvergenceCHAMP, Dis
playWhere

import os
home = os.getenv('HOME')
datapath = os.path.join("/tmp", "database")
path = os.path.join(datapath, "Face_DataBase")
TrSet, TeSet = LoadData('Face', path, decorrelate=False, resize=(65
, 65))
to_display = TrSet[0][0, 0:10, :, :, :]
print('Size=', TrSet[0].shape)
DisplayDico(to_display)
```

Training on a face database

In [ ]:
```
# MP Parameters
nb_dico = 20
width = 9
dico_size = (width, width)
l0 = 20
seed = 42
# Learning Parameters
eta = .05
nb_epoch = 500

TrSet, TeSet = LoadData('Face', path, decorrelate=False, resize=(65
, 65))
N_TrSet, _, _, _ = LocalContrastNormalization(TrSet)
Filtered_L_TrSet = FilterInputData(
    N_TrSet, sigma=0.25, style='Custom', start_R=15)
to_display = Filtered_L_TrSet[0][0, 0:10, :, :, :]
DisplayDico(to_display)

mask = GenerateMask(full_size=(nb_dico, 1, width, width), sigma=0.8
, style='Gaussian')
DisplayDico(mask)
```

Training the ConvMP Layer with homeostasis

In [ ]:
```
from CHAMP.CHAMP_Layer import CHAMP_Layer

from CHAMP.DataTools import SaveNetwork, LoadNetwork
fname = 'cache_dir_CNN/CHAMP_low_None.pkl'
try:
    L1_mask = LoadNetwork(loading_path=fname)
except:
    L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico,
                          dico_size=dico_size, mask=mask, verbose=2)
    dico_mask = L1_mask.TrainLayer(
        Filtered_L_TrSet, eta=eta, nb_epoch=nb_epoch, seed=seed)
    SaveNetwork(Network=L1_mask, saving_path=fname)

DisplayDico(L1_mask.dictionary)
DisplayConvergenceCHAMP(L1_mask, to_display=['error', 'histo'])
DisplayWhere(L1_mask.where)
```

Training the ConvMP Layer with homeostasis

In [ ]:
```
fname = 'cache_dir_CNN/CHAMP_low_HAP.pkl'
try:
    L1_mask = LoadNetwork(loading_path=fname)
except:

    # Learning Parameters
    eta_homeo = 0.0025
    L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico,
                          dico_size=dico_size, mask=mask, verbose=1
)
    dico_mask = L1_mask.TrainLayer(
        Filtered_L_TrSet, eta=eta, eta_homeo=eta_homeo, nb_epoch=nb
_epoch, seed=seed)
    SaveNetwork(Network=L1_mask, saving_path=fname)

DisplayDico(L1_mask.dictionary)
DisplayConvergenceCHAMP(L1_mask, to_display=['error', 'histo'])
DisplayWhere(L1_mask.where)
```

Reconstructing the input image

In [ ]:
```
from CHAMP.DataTools import Rebuilt
import torch
rebuilt_image = Rebuilt(torch.FloatTensor(L1_mask.code), L1_mask.di
ctionary)
DisplayDico(rebuilt_image[0:10, :, :, :])
```

Training the ConvMP Layer with higher-level filters

We train higher-level feature vectors by forcing the network to :

- learn bigger filters,
- represent the information using a bigger dictionary (higher sparseness)
- represent the information with less features (higher sparseness)

In [ ]:
```
fname = 'cache_dir_CNN/CHAMP_high_None.pkl'
try:
    L1_mask = LoadNetwork(loading_path=fname)
except:

    nb_dico = 60
    width = 19
    dico_size = (width, width)
    l0 = 5
    mask = GenerateMask(full_size=(nb_dico, 1, width, width), sigma
=0.8, style='Gaussian')
    # Learning Parameters
    eta_homeo = 0.0
    eta = .05
    nb_epoch = 500
    # learn
    L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico,
                          dico_size=dico_size, mask=mask, verbose=0
)
    dico_mask = L1_mask.TrainLayer(
        Filtered_L_TrSet, eta=eta, eta_homeo=eta_homeo, nb_epoch=nb
_epoch, seed=seed)
    SaveNetwork(Network=L1_mask, saving_path=fname)


DisplayDico(L1_mask.dictionary)
DisplayConvergenceCHAMP(L1_mask, to_display=['error'])#, 'histo'])
DisplayWhere(L1_mask.where)
```

In [ ]:
```
fname = 'cache_dir_CNN/CHAMP_high_HAP.pkl'
try:
    L1_mask = LoadNetwork(loading_path=fname)
except:

    nb_dico = 60
    width = 19
    dico_size = (width, width)
    l0 = 5
    mask = GenerateMask(full_size=(nb_dico, 1, width, width), sigma
=0.8, style='Gaussian')
    # Learning Parameters
    eta_homeo = 0.0025
    eta = .05
    nb_epoch = 500
    # learn
    L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico,
                          dico_size=dico_size, mask=mask, verbose=0
)
    dico_mask = L1_mask.TrainLayer(
        Filtered_L_TrSet, eta=eta, eta_homeo=eta_homeo, nb_epoch=nb
_epoch, seed=seed)
    SaveNetwork(Network=L1_mask, saving_path=fname)

DisplayDico(L1_mask.dictionary)
DisplayConvergenceCHAMP(L1_mask, to_display=['error'])#, 'histo'])
DisplayWhere(L1_mask.where)
```

Training on MNIST database

fname = 'cache_dir_CNN/CHAMP_MNIST_HAP.pkl' try: L1_mask = LoadNetwork(loading_path=fname) except: path = os.path.join(datapath, "MNISTtorch") TrSet, TeSet = LoadData('MNIST', data_path=path) N_TrSet, _, _, _ = LocalContrastNormalization(TrSet) Filtered_L_TrSet = FilterInputData(N_TrSet, sigma=0.25, style='Custom', start_R=15) nb_dico = 60 width = 7 dico_size = (width, width) l0 = 15 # Learning Parameters eta_homeo = 0.0025 eta = .05 nb_epoch = 500 # learn L1_mask = CHAMP_Layer(l0_sparseness=l0, nb_dico=nb_dico, dico_size=dico_size, mask=mask, verbose=2) dico_mask = L1_mask.TrainLayer(Filtered_L_TrSet, eta=eta, eta_homeo=eta_homeo, nb_epoch=nb_epoch, seed=seed) SaveNetwork(Network=L1_mask, saving_path=fname) DisplayDico(L1_mask.dictionary) DisplayConvergenceCHAMP(L1_mask, to_display=['error', 'histo']) DisplayWhere(L1_mask.where)

Computational details

caching simulation data

A convenience script to run and cache most learning items in this notebooks:

In [ ]:
```
!ls -l {shl.cache_dir}/{tag}*
#!rm {shl.cache_dir}/{tag}*lock*
#!rm {shl.cache_dir}/{tag}*
#!ls -l {shl.cache_dir}/{tag}*
```

In [ ]:
```
%%writefile model.py
#!/usr/bin/env python3
# -*- coding: utf-8 -*
tag = 'ICLR'
from shl_scripts.shl_experiments import SHL, prun
# pre-loading data
datapath = '../../SparseHebbianLearning/database'
# different runs
#opts = dict(cache_dir='cache_dir_ICLR', datapath=datapath, verbose
=0)
#opts = dict(cache_dir='cache_dir_cluster', datapath=datapath, verb
ose=0)
opts = dict(datapath=datapath, verbose=0)

shl = SHL(**opts)
data = shl.get_data(matname=tag)

# running main simulations
# Figure 1 & 3
N_cv = 10
homeo_methods = ['None', 'OLS', 'HEH', 'HAP', 'EMP']
seed = 42

# running in parallel on a multi-core machine
import sys
try:
    n_jobs = int(sys.argv[1])
    print('n_jobs=', n_jobs)
except:
    n_jobs = 4
    n_jobs = 9
    n_jobs = 10
    n_jobs = 1
    n_jobs = 35


if n_jobs>0:

    list_figures = []

    from shl_scripts.shl_experiments import SHL_set
    for homeo_method in homeo_methods:
        opts_ = opts.copy()
        opts_.update(homeo_method=homeo_method)
        experiments = SHL_set(opts_, tag=tag + '_' + homeo_method,
N_scan=N_cv)
        experiments.run(variables=['seed'], n_jobs=n_jobs, verbose=
0)

    # Figure 2-B
    variables = ['eta', 'alpha_homeo', 'eta_homeo']
```

```
    variables = ['eta', 'eta_homeo', 'l0_sparseness', 'n_dictionary
']
    bases = [10, 10, 2, 2]

    for homeo_method, base in zip(homeo_methods, bases):
        opts_ = opts.copy()
        opts_.update(homeo_method=homeo_method)
        experiments = SHL_set(opts_, tag=tag + '_' + homeo_method,
base=base)
        experiments.run(variables=variables, n_jobs=n_jobs, verbose
=0)

    # Annex X.X

    shl = SHL(**opts)
    dico = shl.learn_dico(data=data, list_figures=list_figures, mat
name=tag + '_vanilla')

    for algorithm in ['lasso_lars', 'lasso_cd', 'lars', 'elastic',
'omp', 'mp']: # 'threshold',
        opts_ = opts.copy()
        opts_.update(homeo_method='None', learning_algorithm=algori
thm, verbose=0)
        shl = SHL(**opts_)
        dico= shl.learn_dico(data=data, list_figures=[],
                        matname=tag + ' - algorithm={}'.format(algor
ithm))

    for homeo_method in ['None', 'HAP']:
        for algorithm in ['lasso_lars', 'lars', 'elastic', 'omp', '
mp']: # 'threshold', 'lasso_cd',
            opts_ = opts.copy()
            opts_.update(homeo_method=homeo_method, learning_algori
thm=algorithm, verbose=0)
            shl = SHL(**opts_)
            dico= shl.learn_dico(data=data, list_figures=[],
                            matname=tag + ' - algorithm={}'.format(a
lgorithm) + ' - homeo_method={}'.format(homeo_method))

    shl = SHL(one_over_F=False, **opts)
    dico_w = shl.learn_dico(data=data, matname=tag + '_WHITE', list
_figures=[])
    shl = SHL(one_over_F=True, **opts)
    dico_1oF = shl.learn_dico(data=data, matname=tag + '_OVF', list
_figures=[])

    shl = SHL(beta1=0., **opts)
    dico_fixed = shl.learn_dico(data=data, matname=tag + '_fixed',
list_figures=[])
    shl = SHL(**opts)
    dico_default = shl.learn_dico(data=data, matname=tag + '_defaul
t', list_figures=[])
```

In [ ]:

```
%run model.py 0
```

Version used

In [ ]:
```
%load_ext version_information
%version_information numpy, shl_scripts
```

version control

In [ ]:
```
!git status
```

In [ ]:
```
!git pull
```

In [ ]:
```
!git commit -am' {tag} : re-running notebooks'
```

In [ ]:
```
!git push
```

exporting the notebook

In [ ]:
```
!jupyter nbconvert Annex.ipynb
```

In [ ]:
```
#!jupyter-nbconvert --template report --to pdf Annex.ipynb
```

In [ ]:
```
!pandoc Annex.html -o Annex.pdf
```

In [ ]:
```
!zip Annex.zip Annex.html
```

Done. Thanks for your attention!