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Spontaneous and Task-related Activation of Neuronally Correlated Events (STANCE)

Illustates the simulation of a 4D fMRI data set from specifying the experimental design and 3D activation maps for corresponding tasks.

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```
close all;
clear all; %#ok<CLALL>
currentDir = pwd;
if strcmp(currentDir(end-2:end),'GUI')
    % GUI instance of initialization
    cd ../
    STANCEroot = pwd;
    cd(currentDir)
elseif strcmp(currentDir(end-5:end),'STANCE')
    STANCEroot = pwd;
elseif strcmp(currentDir(end-16:end),'scripts_for_demos')
    cd ../
    STANCEroot = pwd;
else
    hSTANCE = msgbox('Please select the STANCE directory');
    uiwait(hSTANCE);
    currPath = fileparts(mfilename('fullpath'));
    STANCEroot = uigetdir(currPath, 'Add STANCE filepath');
end
cd(STANCEroot)
addpath(genpath(pwd));

% Load STANCE globals ...
if ~exist('STANCE.mat','file')
    STANCE_initialize_STANCE;
    load('STANCE.mat');
else
    load('STANCE.mat');
```

```
end
% NOTE: Must add SPM version to filepath prior to usage
addpath(SPMpath);
if exist(spm('Dir'),'dir')
    display('o SPM installation found.')
else
    warning('SPM installation not found. Please add to MATLAB filepath
 or install.')
    warning('SPM8 installation: http://www.fil.ion.ucl.ac.uk/spm/
software/spm8/')
    exit
end
```

```
o SPM installation found.
```

Turn off warnings...

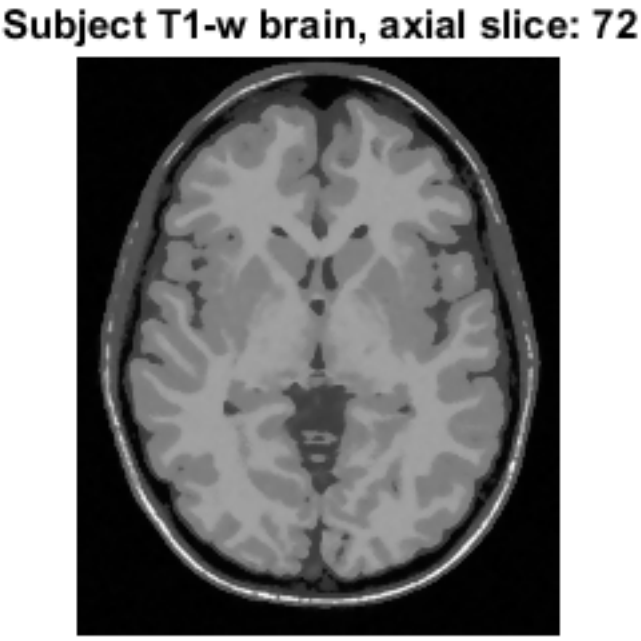
... OpenGl warnings

```
warning('off','MATLAB:opengl:StartupBlacklistedNoSetting');
warning('off', 'MATLAB:hg:AutoSoftwareOpenGL');
% ... finite warning
warning('off', 'MATLAB:FINITE:obsoleteFunction');
% ... NIFTI class warnings when loading SPM mat files
warning('off', 'MATLAB:unknownElementsNowStruc');
warning('off', 'MATLAB:dispatcher:ShadowedMEXExtension');
warning('off', 'MATLAB:pfileOlderThanMfile');
% ... removing files from path
warning('off', 'MATLAB:RMDIR:RemovedFromPath');
warning('off', 'MATLAB:DELETE:FileNotFound');
```

Select subject by index (originally there are 20 subjects to choose from)

```
subject_brain = 5;
Now_sss = [4 1 1];
filepathOut = STANCE_genpath(Now_sss);
if ~logical(exist(filepathOut,'file'))
    STANCE_new_session(Now_sss);
end
makeFMRI = true;

% for reproducibility
s = 0;
%s = []; % allow MATLAB to spontaneously shuffle
if ~isempty(s)
    rng(s,'twister');
end

% show MNI volume conformed to BrainWEB dimensions
[V_MNI,Y_MNI] = STANCE_load_volume(filenameMNI);
MNI_dim = V_MNI.dim;
```

```
MNI_mat = V_MNI.mat;
origin  = abs(V_MNI.mat(1:3,4))';

[~,I_max] = max(sum(sum(Y_MNI)));
showSlice = I_max(1);

% figure, imshow(imrotate(Y_MNI(:,:,showSlice),90),[]), drawnow;
% TITLE = ['MNI152 brain, A slice: ',num2str(showSlice)];
% title(TITLE)

% load the T1w data for subject, for display purposes
[V_T1w,Y_T1w] = STANCE_choose_subject(subject_brain,'T1');

T1w_dim = V_T1w.dim;  % dimensions of T1-w volume
T1w_mat = V_T1w.mat;  % 4x4 homographic matrix relating indeces to
 real-world coordinates
f1 = figure;
subplot(2,1,2)
imshow(imrotate(Y_T1w(:,:,showSlice),90),[]), drawnow;
TITLE = ['Subject T1-w brain, axial slice: ',num2str(showSlice)];
title(TITLE)
truesize
movegui(f1,'northwest');

% retrieve transfromation matrix mapping MNI152 to subject's native
 space
M = M_array(:,:,subject_brain);

[V_MNI_reg,Y_MNI_reg] = STANCE_register_MNI(V_T1w.fname,M);

% figure, imshow(imrotate(Y_MNI_reg(:,:,showSlice),90),[]), drawnow;
% TITLE = ['MNI152 registered to subject brain, A slice:
 ',num2str(showSlice)];
% title(TITLE)

dimensions = size(Y_T1w);
origin = round(abs(V_T1w.mat(1:3,4)))';
```



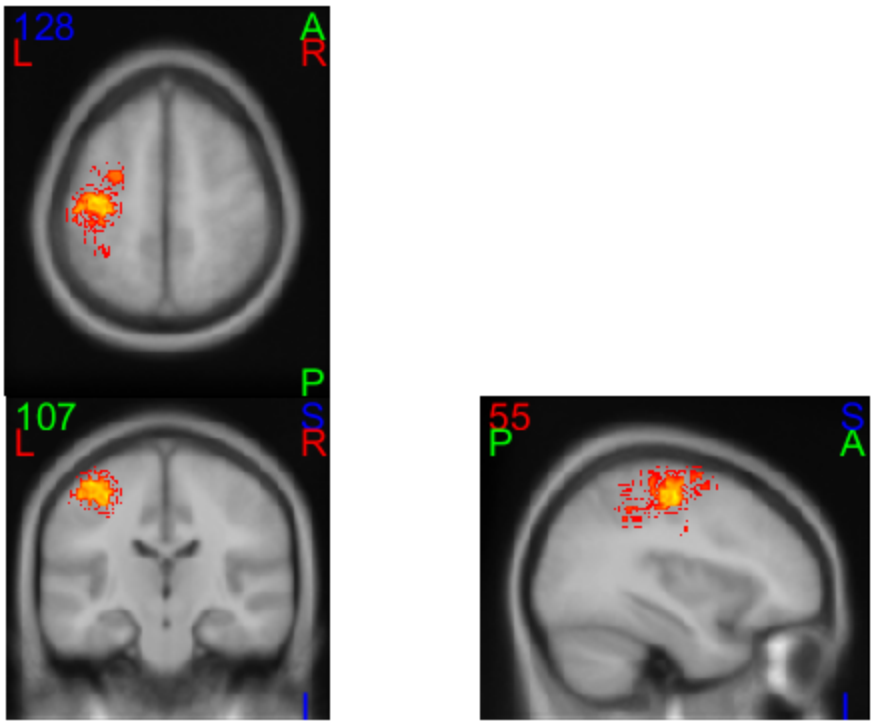
Build activation regions by modelling reported results

```
% load activation map from data files
clear task;

uiwait(msgbox('Demo example of a finger related task data from
 NeuroSynth.','Finger meta-analysis data','modal'));

% NeuroSynth finger tapping example
task.name = 'Finger Tapping';
task.activation(1).region   = [STANCEroot,'/activations/finger
 tapping_pFgA_z_FDR_0.01.nii.gz'];
task.activation(1).shape    = 'data'; % data derived by forward
 inference
task.activation(1).volume   = [];        % the index for 4D data
task.activation(1).proportion = 5.0;     % the activation thresholds:
 [lower, saturation]
%~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
task.activation(2).region   = [STANCEroot,'/activations/finger
 tapping_pAgF_z_FDR_0.01.nii.gz'];
task.activation(2).shape    = 'data'; % data derived by reverse
 inference
task.activation(2).proportion = 5.0;     % the activation thresholds:
 [lower, saturation]
```

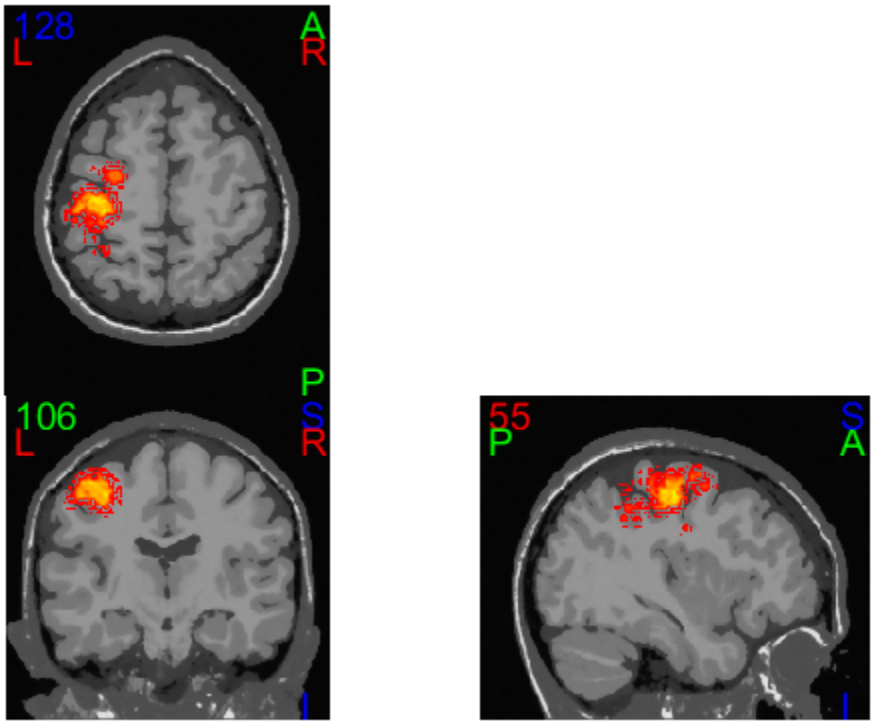
```
task.combine{1} = {'OR','all'};
task.combine{2} = {'AND','flip'};
task.combine{3} = {'mask','L'};
% define signal amplitude
task.amplitude = 0.03; % 3% activation

if exist('simulations.mat','file')
    load('simulations.mat');
else
    % create simulations struct
end
simulations{Now_sss(1)}.task{1} = task;

% left brain component of right-handed task
disp('Defining finger tapping task activation map...')
task.activation(1).map =
 STANCE_load_map(task.activation(1).region,V_MNI,5.0,false);
task.activation(2).map =
 STANCE_load_map(task.activation(2).region,V_MNI,5.0,false);

disp('o Combining finger tapping task activation maps from data
 files...')
task.map = STANCE_parse_combine(task);
% % explictly this does the following
% task.map = STANCE_combine_maps('OR',task.activation(:).map);
% % combine activation in opposite hemispheres
% task.map = STANCE_combine_maps('AND',task.map,flipud(task.map));
% % restrict to activation due to tasks on the R hand
% task.map(ceil(0.5*dimensions(1)):end,:,:) = 0;

% supress bright artefact on medial surface and inferior area
task.map(ceil(0.38*dimensions(1)):end,:,:) =
 0; %0.1*task_R.map(ceil(0.4*dimensions(1)):end,:,:);
task.map(:,:,1:90) = 0;

% find the ammount of gray matter volume for the activation map based
 on MNI tissue priors
task.GMvolume = STANCE_find_GM_volume(task);

% free up working memory (optional)
% task.activation(1).map = [];
% task.activation(2).map = [];

TITLE = {'R Finger Tapping Task','from NeuroSynth data: MNI'};
htask2 = STANCE_display_activation_slice(Y_MNI,task.map,[],[]);
title(TITLE)
movegui(htask2,'center');

% h_task_TS_R =
 STANCE_display_activation_slice(Y_MNI,task.map,showSliceTS,1);
% title('R Finger Tapping Task from NeuroSynth: S')
%
% h_task_TC =
 STANCE_display_activation_slice(Y_MNI,task.map,showSliceTC,2);
```

```
% title('R Finger Tapping Task from NeuroSynth: C')

[V_finger_tapping_reg,Y_finger_tapping_reg] =
 STANCE_register_activation(V_T1w.fname,task);

% figure, imshow(imrotate(Y_finger_tapping_reg(:,:,showSliceTA),90),
[]), drawnow;
% title('Finger tapping task activation of the PSM registered')

%h_task_reg =
 STANCE_display_activation_slice(Y_MNI_reg,Y_finger_tapping_reg,[]);
%title('Finger tapping task activation of the PSM registered')

% Finger tapping task activation template of the PSM of subject
TITLE = {'Finger tapping task'; 'activation template in subject'};
htask1sub =
 STANCE_display_activation_slice(Y_T1w,Y_finger_tapping_reg,[],[]);
title(TITLE)
movegui(htask1sub,'center');

% make room in memory
if ~strcmp(V_T1w.fname(end-1:end),'gz')
    delete(V_T1w.fname);
end
clear('V_T1w','YT1w');
delete(V_MNI_reg.fname);
clear('V_MNI_reg','Y_MNI_reg')
task.activation(1).map = [];        % clear memory
task.activation(2).map = [];        % clear memory

% save activation template
task.map = int8(255*task.map);
cd([STANCEroot,'/activations'])
save([task.name,'.mat'],'task')
cd(STANCEroot)
task.map = [];
%

Defining finger tapping task activation map...
o Loading map from data in C:\spm\STANCE/activations/finger
 tapping_pFgA_z_FDR_0.01.nii.gz.
o Loading map from data in C:\spm\STANCE/activations/finger
 tapping_pAgF_z_FDR_0.01.nii.gz.
o Combining finger tapping task activation maps from data files...
```

R Finger Tapping Task
from NeuroSynth data: MNI



Finger tapping task
activation template in subject



Reslice to funtional space according to the fMRI scan protocol

```
if makeFMRI == true

% define scan protocol parameters for finger tapping task based on
 those detailed
% in Tables 1. & 3. of "Functional Mapping of Human Sensorimotor
 Cortex with
% 3D BOLD fMRI Correlates Highly With H2150 PET rCBF" in Journal of
 Cerebral Blood Flow and Metabolism
% 16:755-764
choiceFlag = 0;
cd(STANCE_genpath(Now_sss,2))
if logical(exist([STANCE_genpath(Now_sss,2),'/
STANCEsubject.mat'],'file'))
    cd(STANCE_genpath(Now_sss))
    if logical(exist([STANCE_genpath(Now_sss),'/
STANCEscan.mat'],'file'))
        % Construct a questdlg with two options
        choice = questdlg('Previous scan found for this subject and
 session, load info?', ...
     'Scan found', ...
     'Yes','No','No');
        % Handle response
        switch choice
            case 'Yes'
                load('STANCEscan.mat')
                cd(STANCE_genpath(Now_sss,2))
                load('STANCEsubject.mat')
                choiceFlag = 1;
            case 'No'
                STANCE_new_session(Now_sss);
        end
    end
end
cd(STANCEroot)
if ~choiceFlag
    scan.voxel.size    = [3 3 3];      % [3.75 3.75 3.75] in original
 experiment
    scan.voxel.matrix  = [64 64 NaN];  % [64 50 24]; in original
 experiment
    scan.voxel.spacing = [0 0 0.2*scan.voxel.size(3)]; % assume 20% Z
 spacing
    scan.tiltAngle     = 0;    % [degrees] tilt angle
    scan.TR            = 2400; % [ms] repetion time
    scan.TE            = 35;   % [ms] echo time
    scan.ES            = 0.51; % [ms] echo spacing
    scan.FA            = 11;   % [degrees] flip angle
    scan.BW            = 2232; % [Hz/Px]
    scan.order         = 'SD'; % SD = sequential descending order
```

```
    scan.KM0           = 2225; % fit to data with max of 909 at 3T and
 FA = 90 degree  (Siemens 3T ~4000)
    scan.noise_method  = 'percent';
    scan.noise         = 0;    % percent noise relative to peak
    scan.attenuation   = 0;  % coil attenuation factor ~mm^-1
    % FWHM ~4.5 mm

    simulations{Now_sss(1)}.scan = scan;
    save('simulations.mat','simulations')

    % load tissue fuzzy memberships in subject's native space
    [V_fuzzy,~] = STANCE_choose_subject(subject_brain,'fuzzy',true);
    fn_tissue = [V_fuzzy(1).fname,'.gz'];

    % generate the tissue fuzzy memberships in functional space
    [V_reslice,Y_reslice] = STANCE_reslice_tissue(fn_tissue,scan,[],
[],false,Now_sss); % change the last arg to 'true' to show figures
    sliceLimits =
 [V_reslice(1).sliceLimitLower,V_reslice(1).sliceLimitUpper];

    % figure, imshow(imrotate(Y_reslice(:,:,showSlice2,3),90),[]);
    % TITLE = ['Reslice tissue priors - gray matter, A
 slice:',num2str(showSlice2TA)];
    % title(TITLE)
    fn_fuzzy_reslice = V_reslice(1).fname;

    [~,I_max] = max(sum(sum(Y_reslice(:,:,:,3))));
    showSlice2 = I_max(1);

    % generate T2* baseline volume in functional space
    display('o Generating T2* baseline volume in functional space.')
    [V_T2star_Map,Y_T2star_Map] =
 STANCE_make_parameter_map(fn_fuzzy_reslice,'T2star');
    scrsz = get(groot,'ScreenSize');
    positionVector2 = [scrsz(3)/2.5 scrsz(4)/2.5 scrsz(3)/5
 scrsz(4)/3];
    f2 = figure;
    imshow(imrotate(Y_T2star_Map(:,:,showSlice2),90),[])
    title('T2* baseline volume')
    set(f2,'OuterPosition',positionVector2);
    movegui(f2,'north')

    % project activation map on to functional space
    [V_finger_tapping_reslice,Y_finger_tapping_reslice] =
 STANCE_reslice_volume(V_finger_tapping_reg,scan,sliceLimits);
    [~,I_max] = max(sum(sum(Y_finger_tapping_reslice)));
    showSlice2TA = I_max(1);
    TITLE = {'Finger tapping task,'; ['functional axial:
',num2str(showSlice2TA)]};
    f3 = figure;
    imshow(imrotate(Y_finger_tapping_reslice(:,:,showSlice2TA),90),[])
    title(TITLE)
    set(f3,'OuterPosition',positionVector2);
    movegui(f3,'northeast')
```

```
    delete(V_finger_tapping_reg.fname);

    % mask with gray matter mask
    [Y_finger_tapping_reslice,Y_GM] =
 STANCE_GM_mask(Y_finger_tapping_reslice,task.GMvolume,Now_sss);
    %figure,
 imshow(imrotate(Y_finger_tapping_reslice(:,:,showSlice2TA),90),[]);

    subjectActivation3D{1} = Y_finger_tapping_reslice;

    cd(STANCE_genpath(Now_sss))

 save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits','subjectActivation3
    cd(STANCEroot)

else
    % load the tissue fuzzy memberships in functional space
    [V_reslice,Y_reslice] = STANCE_load_volume(fn_fuzzy_reslice);
    [~,I_max] = max(sum(sum(Y_reslice(:,:,:,3))));
    showSlice2 = I_max(1);
    Y_finger_tapping_reslice = squeeze(subjectActivation3D{1});

    % generate T2* baseline volume in functional space
    display('o Generating T2* baseline volume in functional space.')
    [V_T2star_Map,Y_T2star_Map] =
 STANCE_make_parameter_map(fn_fuzzy_reslice,'T2star');
    scrsz = get(groot,'ScreenSize');
    positionVector2 = [scrsz(3)/2.5 scrsz(4)/2.5 scrsz(3)/5
 scrsz(4)/3];
    f2 = figure;
    imshow(imrotate(Y_T2star_Map(:,:,showSlice2),90),[])
    title('T2* baseline volume')
    set(f2,'OuterPosition',positionVector2);
    movegui(f2,'north')

    % mask with gray matter mask
    [Y_finger_tapping_reslice,Y_GM] =
 STANCE_GM_mask(Y_finger_tapping_reslice,task.GMvolume,Now_sss);
    %figure,
 imshow(imrotate(Y_finger_tapping_reslice(:,:,showSlice2TA),90),[]);
end

% save all of the elements common to the subject
cd(STANCE_genpath(Now_sss,2))
save('STANCEsubject.mat','Now_sss','subject_brain','fn_tissue','fn_fuzzy_reslice',
cd(STANCEroot)

clear subjectActivation3D;

[~,I_max] = max(sum(sum(Y_finger_tapping_reslice)));
showSlice2TA = I_max(1);

% add activation to T2* baseline
disp('Adding activation to the T2* baseline ...')
```

```
[V_T2star_Map_Act,Y_T2star_Map_Act] =
 STANCE_add_activation(V_T2star_Map.fname,Y_finger_tapping_reslice,scan.TE,task.am
TITLE = {'T2* map w/ BOLD activation,', ['Axial slice:
 ',num2str(showSlice2TA)]};
f4 = figure;
imshow(imrotate(Y_T2star_Map_Act(:,:,showSlice2TA),90),[])
title(TITLE)
set(f4,'OuterPosition',positionVector2);
movegui(f4,'east')
% figure, imshow(imrotate(Y_T2star_Map_Act(:,:,showSlice2TA),90)-
imrotate(Y_T2star_Map(:,:,showSlice2TA),90),[]);
% TITLE = ['T2* map activation - baseline, A
 slice:',num2str(showSlice2TA)];
% title(TITLE)
```

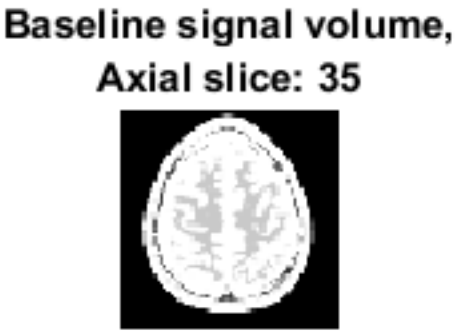
```
Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session001.
Warning: Directory already exists.
Reslicing gray matter fuzzy membership labels...
Reslicing background fuzzy membership labels...
Reslicing CSF fuzzy membership labels...
Reslicing white matter fuzzy membership labels...
Reslicing fat fuzzy membership labels...
Reslicing muscle fuzzy membership labels...
Reslicing skin fuzzy membership labels...
Reslicing skull fuzzy membership labels...
Reslicing blood vessels fuzzy membership labels...
Reslicing connective tissue fuzzy membership labels...
Reslicing dura matter fuzzy membership labels...
Reslicing bone marrow fuzzy membership labels...
o Generating T2* baseline volume in functional space.
Adding activation to the T2* baseline ...
```

Generate the EPI baseline

```
disp('Generating the EPI baseline ...')
[V_EPI0,Y_EPI0] =
 STANCE_EPI_signal(fn_fuzzy_reslice,Y_T2star_Map,scan);
% figure, imshow(imrotate(Y_EPI0(:,:,showSlice2TA),90),[]);
TITLE = {'Gray matter priors,', ['axial
 slice:',num2str(showSlice2TA)]};
f5 = figure;
imshow(imrotate(Y_GM(:,:,showSlice2TA),90),[])
title(TITLE)
set(f5,'OuterPosition',positionVector2);
movegui(f5,'southeast')

maxS = max(Y_EPI0(:).*Y_GM(:));
TITLE = {'Baseline signal volume,',['Axial slice:
 ',num2str(showSlice2TA)]};
f6 = figure;
imshow(imrotate(Y_EPI0(:,:,showSlice2TA),90),[0,maxS])
title(TITLE)
set(f6,'OuterPosition',positionVector2);
movegui(f6,'south')
```

```
Generating the EPI baseline ...
```

```
o Writing C:\spm\STANCE/fMRI/study004/subject0001/
session001\EPI_BOLD_0001_001.nii
The maximum intensity of the simulated signal: 253.9648
```

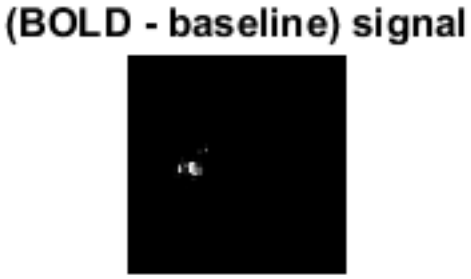


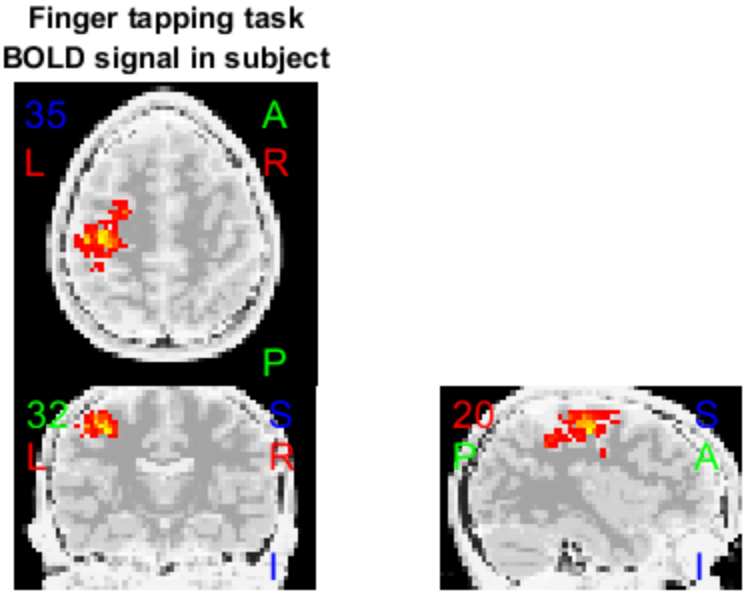
Generate the pristine EPI signal

```
disp('Generating the pristine EPI signal ...')
Now_sss = [4 1 2];
STANCE_new_session(4,1,2,true);

% exact EPI signal, no noise, no attenuation
[V_EPI,Y_EPI] =
 STANCE_EPI_signal(fn_fuzzy_reslice,Y_T2star_Map_Act,scan);
maxS = max(Y_EPI(:).*Y_GM(:));
TITLE = {'Exact BOLD signal,',['Axial slice:
 ',num2str(showSlice2TA)]};
f7 = figure;
imshow(imrotate(Y_EPI(:,:,showSlice2TA),90),[0,maxS])
title(TITLE)
set(f7,'OuterPosition',positionVector2);
movegui(f7,'southwest')

f8 = figure;
```

```
imshow(imrotate(Y_EPI(:,:,showSlice2TA),90)-
imrotate(Y_EPI0(:,:,showSlice2TA),90),[])
title('(BOLD - baseline) signal')
set(f8,'OuterPosition',positionVector2);
movegui(f8,'west')

% Finger tapping task activation of the PSM in subject
TITLE = {'Finger tapping task', 'BOLD signal in subject'};
htask1subfun =
 STANCE_display_activation_slice(Y_EPI,Y_finger_tapping_reslice,[],
[]);
title(TITLE)
movegui(htask1subfun,'center');

cd(STANCE_genpath)
save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits')
cd(STANCEroot)
```

Generating the pristine EPI signal ...
Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session002.
o Writing C:\spm\STANCE/fMRI/study004/subject0001/
session002\EPI_BOLD_0001_002.nii
The maximum intensity of the simulated signal: 253.9648



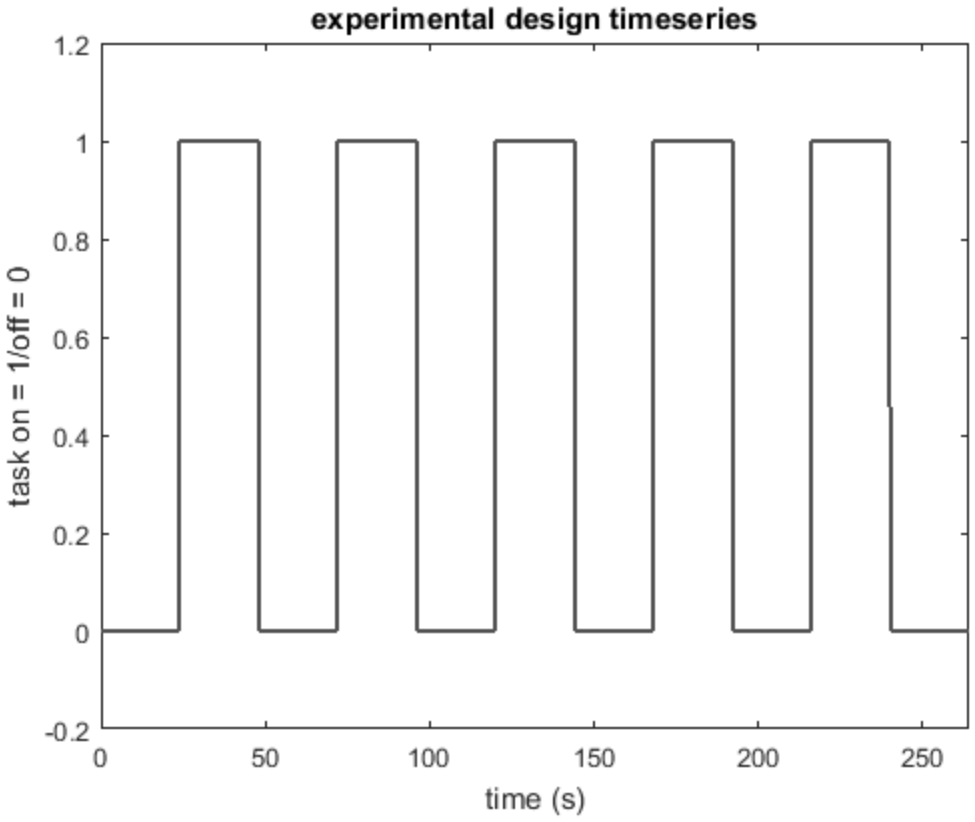


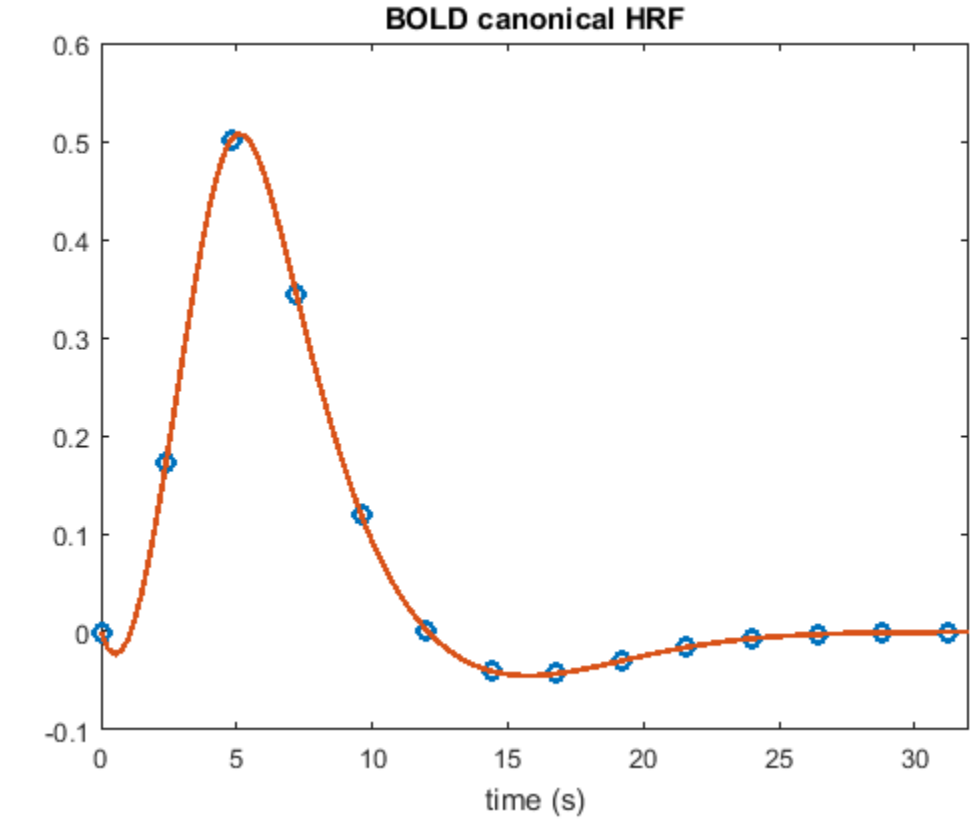
Design the 4D time-series

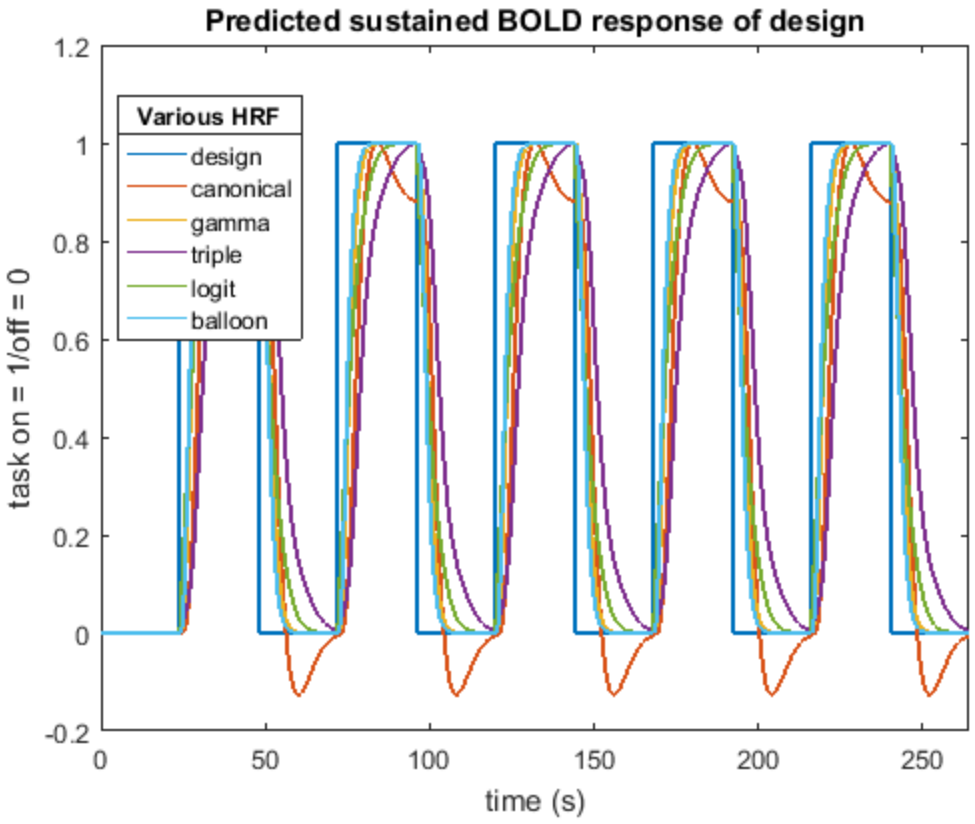
```
disp('Constructing the experiment design unto the 4D time-series ...')
uiwait(msgbox('Constructing experiment design and response.','4D time-
series'));

tic
Nslices = size(Y_T2star_Map,3);
TRsec = scan.TR/1000;
dt = TRsec/Nslices;
exp_design = STANCE_blocked_design(dt, 24, 24, 24, 24*11);
Nt = length(exp_design.Data);
times = dt*(1:Nt)';
NT = (Nt/Nslices);

h_expdesign = figure;
plot(exp_design,'LineWidth', 1.5,'Color',[0.33,0.33,0.33]);
ylim([-0.2 1.2])
xlim([0 times(end)])
xlabel('time (s)')
ylabel('task on = 1/off = 0')
title('experimental design timeseries')
movegui(h_expdesign,'northwest');

% display canonical HRF
```

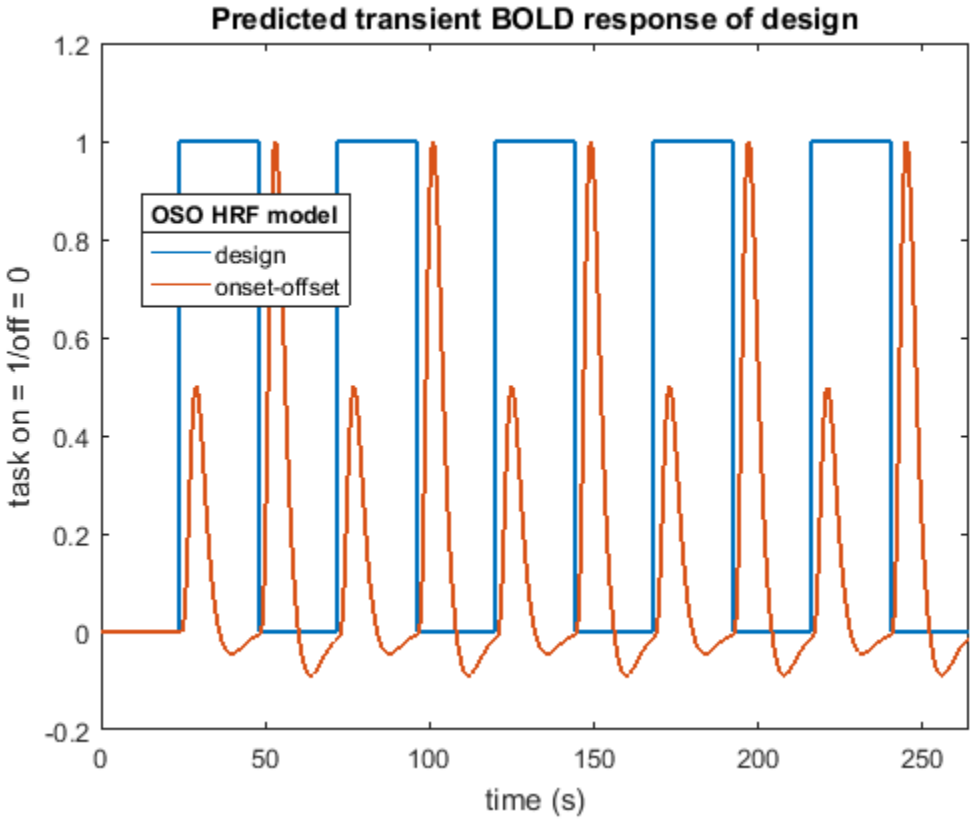
```
hrf = spm_hrf(TRsec);
times2 = 0:0.25:32;
hrf_exact = spline(0:TRsec:32,hrf,times2);
h_hrf = figure;
plot(0:TRsec:32,hrf,'o',times2,hrf_exact,'LineWidth',2.0);
xlim([0,32])
xlabel('time (s)')
title('BOLD canonical HRF')
movegui(h_hrf,'northeast');

toc

% save all of the elements common to the study
cd(STANCE_genpath(Now_sss,1))
save('STANCEstudy.mat','task','exp_design')
cd(STANCEroot)


tic

% apply canonical HRF to experimental design
BOLD_ts = STANCE_apply_response_function(dt,exp_design);
baseline_ts = (1-BOLD_ts.Data);

BOLD_gamma_ts = STANCE_apply_response_function(dt,exp_design,'gamma');
BOLD_triple_ts =
 STANCE_apply_response_function(dt,exp_design,'triple');
BOLD_logit_ts = STANCE_apply_response_function(dt,exp_design,'logit');
BOLD_balloon_ts =
 STANCE_apply_response_function(dt,exp_design,'balloon');

h_predictedBOLD = figure;
plot(times,exp_design.Data,times,BOLD_ts.Data,times,BOLD_gamma_ts.Data,times,BOLD_
ylim([-0.2 1.2])
xlim([0 times(end)])
xlabel('time (s)')
ylabel('task on = 1/off = 0')
title('Predicted sustained BOLD response of design')
lgdBOLD =
 legend('design','canonical','gamma','triple','logit','balloon','Location','best')
title(lgdBOLD,'Various HRF')
movegui(h_predictedBOLD,'southwest');

BOLD_OO_ts = STANCE_apply_response_function(dt,exp_design,[],[],
[],'on-off',0.5);
h_predictedOOBOLD = figure;
plot(times,exp_design.Data,times,BOLD_OO_ts.Data,'LineWidth',1.25);
ylim([-0.2 1.2])
xlim([0 times(end)])
xlabel('time (s)')
ylabel('task on = 1/off = 0')
title('Predicted transient BOLD response of design')
lgdOOBOLD = legend('design','onset-offset','Location','best');
title(lgdOOBOLD,'OSO HRF model')
```

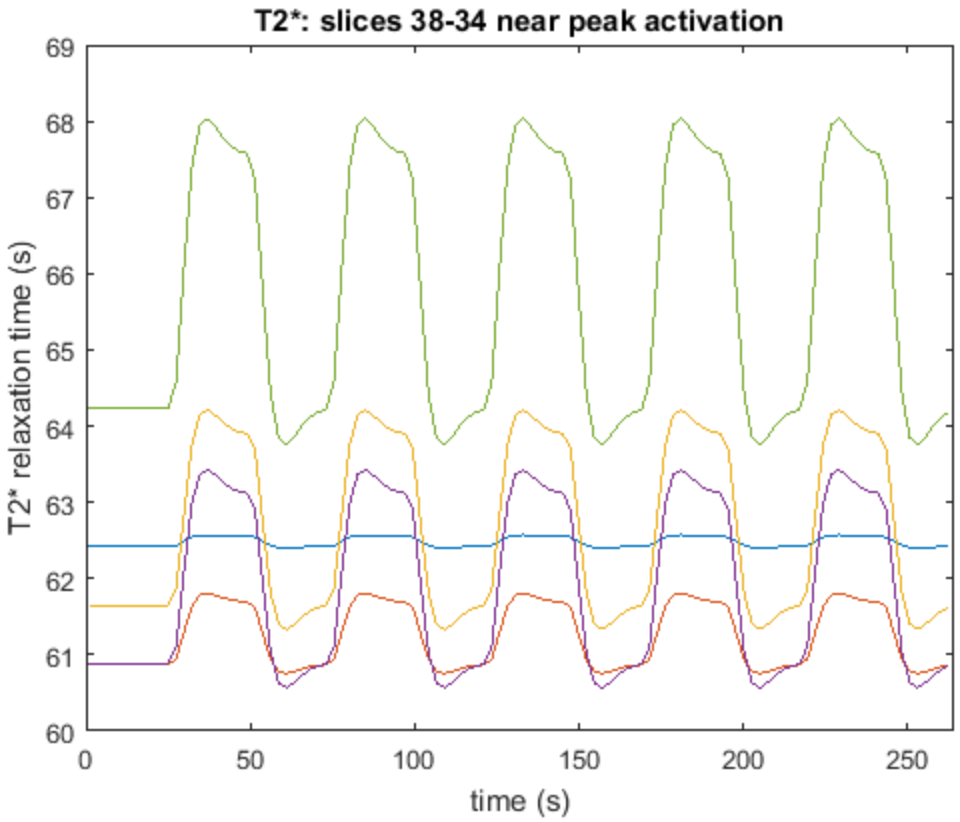
```
movegui(h_predictedOOBOLD,'northwest');

clear BOLD_gamma_ts
  BOLD_triple_ts BOLD_logit_ts BOLD_balloon_ts BOLD_OO_ts;

T2star_4D =
 zeros(size(Y_T2star_Map,1),size(Y_T2star_Map,2),Nslices,NT);

sliceOrder = scan.order;
sliceTiming = make_slice_timing(sliceOrder,Nslices);

for t = 1:Nt
    ti = ceil(t/Nslices);
    STi = mod(t,Nslices);
    if STi == 0
        STi = Nslices;
    end
    T2star_4D(:,:,sliceTiming(STi),ti) =
 Y_T2star_Map(:,:,sliceTiming(STi))*baseline_ts(t) +
 Y_T2star_Map_Act(:,:,sliceTiming(STi))*BOLD_ts.Data(t);
end

Times = 1:TRsec:NT*TRsec;
figure,
plot(Times,squeeze(T2star_4D(20,32,38,:)),Times,squeeze(T2star_4D(20,32,37,:)),Tim
xlim([0 times(end)])
xlabel('time (s)')
ylabel('T2* relaxation time (s)')
title('T2*: slices 38-34 near peak activation')

Now_sss = [4 1 3];
STANCE_new_session(4,1,3,true);

Constructing the experiment design unto the 4D time-series ...
Elapsed time is 0.746251 seconds.
o Applying the canonical hemodynamic response function to time-series.
o Applying the Gamma distribution response function to time-series.
o Applying the triple Gamma response function to time-series.
o Applying the triple logit response function to time-series.
o Applying the balloon response to the time-series.
Warning: Default parameter values are used.

model =

on-off

o Applying the canonical hemodynamic response function to time-series.
Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session003.
```


experimental design timeseries
task on = 1/off = 0
time (s)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250


BOLD canonical HRF
time (s)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
5
10
15
20
25
30


Predicted sustained BOLD response of design
Various HRF
design
canonical
gamma
triple
logit
balloon
task on = 1/off = 0
time (s)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250


Predicted transient BOLD response of design
OSO HRF model
design
onset-offset
task on = 1/off = 0
time (s)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
0
50
100
150
200
250

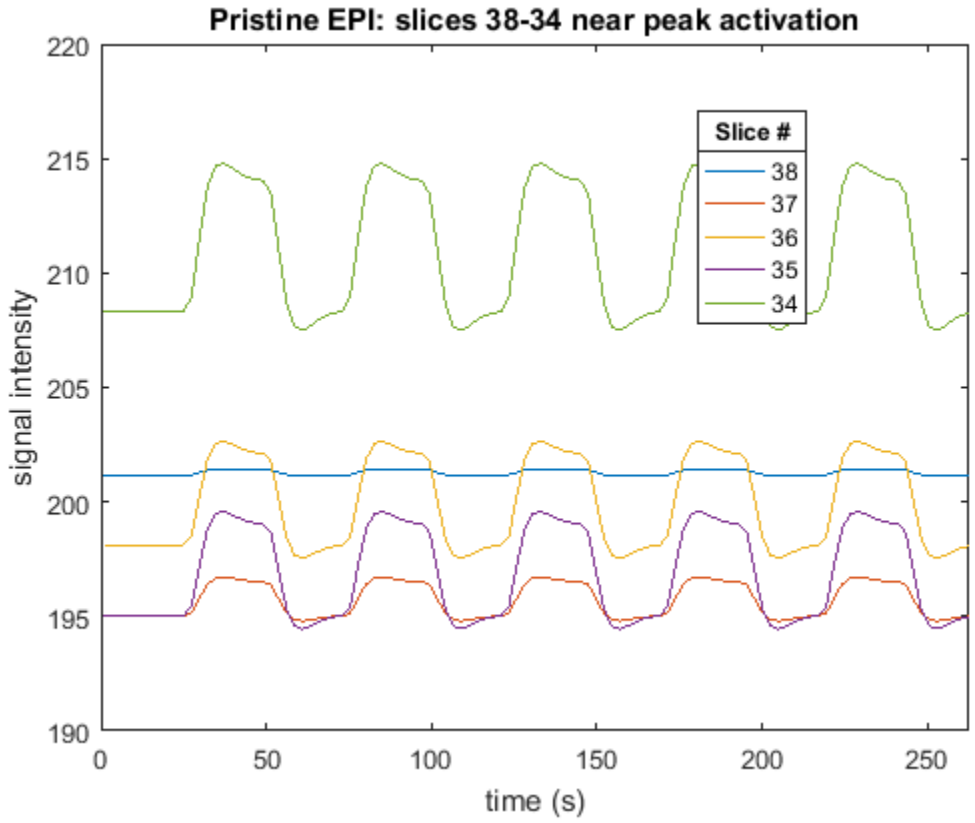


Generate the pristine EPI timeseries with no noise or motion

```
uiwait(msgbox('Generating pristine EPI 4D signal.','Pristine 4D
 data'));

display('o Generating pristine EPI 4D signal.')

% save all of the elements common to the session's scan
cd(STANCE_genpath(Now_sss))
save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits','exp_design')
cd(STANCEroot)

[~,Y_EPI4D] = STANCE_EPI_signal(fn_fuzzy_reslice,T2star_4D,scan);

% from figure 11 peak activation near: X = 20, Y  = 32, Z = 34

Times = 1:TRsec:NT*TRsec;
h_EPI0 = figure;
plot(Times,squeeze(Y_EPI4D(20,32,38,:)),Times,squeeze(Y_EPI4D(20,32,37,:)),Times,s
title('Pristine EPI: slices 38-34 near peak activation')
lgd = legend('38','37','36','35','34','Location','best');
xlabel('time (s)')
ylabel('signal intensity')
```

```
axis([0 Times(end) 190 220])
title(lgd,'Slice #')
movegui(h_EPI0,'center');
```

```
o Generating pristine EPI 4D signal.
o Writing C:\spm\STANCE/fMRI/study004/subject0001/
session003\EPI_BOLD_0001_003.nii
The maximum intensity of the simulated signal: 253.9648
```

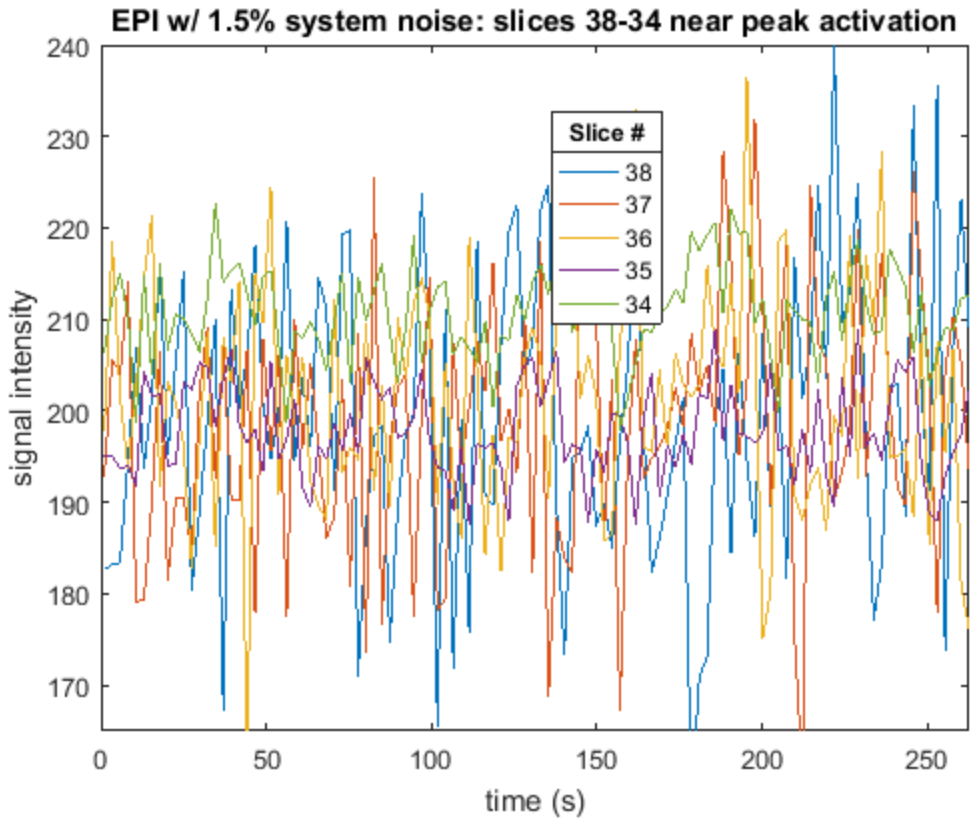


Add spatially varying system noise

```
uiwait(msgbox('Generating EPI 4D signal with system noise that varies
 with tissue type.','4D data + noise'));

Now_sss = [4 1 4];
STANCE_new_session(4,1,4,true);

scan.noise            = 1.5;    % percent noise relative to peak
noiseMap = STANCE_make_noise_map(fn_fuzzy_reslice,2,4);

% save all of the elements common to the session's scan
cd(STANCE_genpath(Now_sss))
save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits','exp_design','noiseM
cd(STANCEroot)

% EPI timeseries, with system noise, no attenuation
```

```
[~,Y_EPI4D] =
 STANCE_EPI_signal(fn_fuzzy_reslice,T2star_4D,scan,noiseMap,[],[],[],
[],s+2*Nt);

toc

% from figure 11 peak activation near: X = 20, Y  = 32, Z = 34

Times = 1:TRsec:NT*TRsec;
h_EPIn = figure;
plot(Times,squeeze(Y_EPI4D(20,32,38,:)),Times,squeeze(Y_EPI4D(20,32,37,:)),Times,s
title('EPI w/ 1.5% system noise: slices 38-34 near peak activation')
xlabel('time (s)')
ylabel('signal intensity')
axis([0 Times(end) 165 240])
lgdn = legend('38','37','36','35','34','Location','best');
title(lgdn,'Slice #')
movegui(h_EPIn,'northwest');
```

Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session004.
o Writing C:\spm\STANCE/fMRI/study004/subject0001/
session004\EPI_BOLD_0001_004.nii
The maximum intensity of the simulated signal: 372.9436
Elapsed time is 22.932319 seconds.

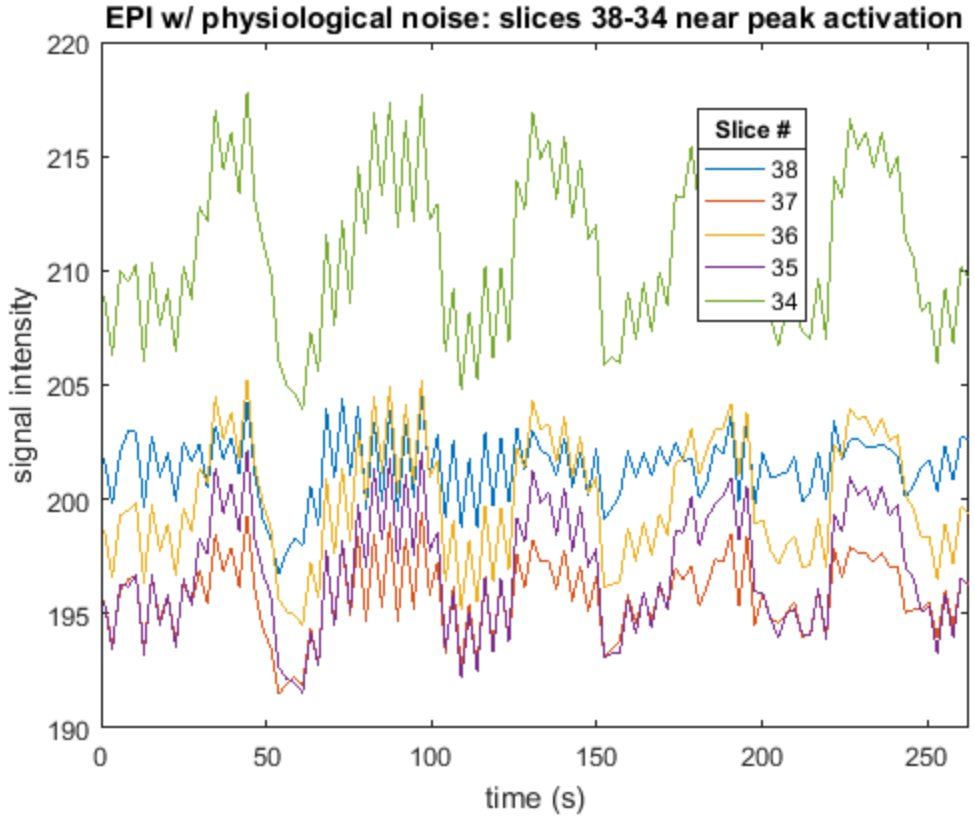


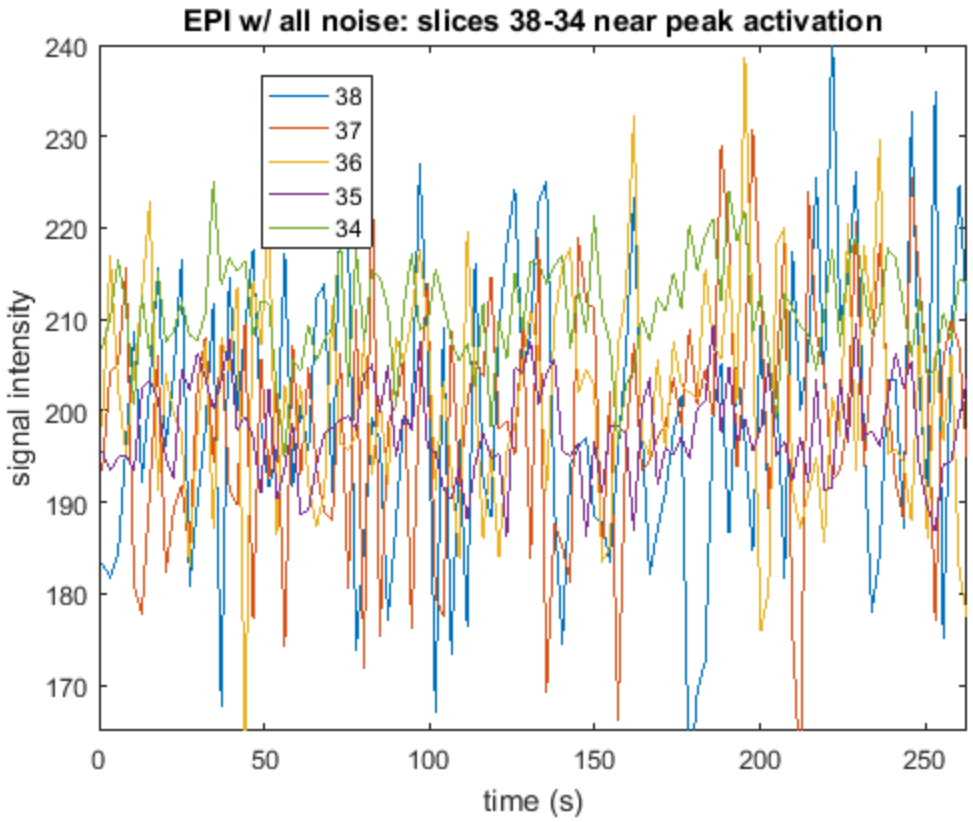
Add physiological noise times-series

```
uiwait(msgbox('Generating EPI 4D signal with only physiological noise
 added.','4D data + physio'));

disp('Adding physiological noise to the times-series ...')
Now_sss = [4 1 5];
STANCE_new_session(4,1,5,true);

% define physiological noise parameters
physio.weight                  = 75.0;  % [kg] weight
physio.lambdas                 = [0.009,0.006,0.02,0.05]; % lambda
 values for major tissue types according to the tSNR model
physio.respiratory.TI          = 4.8;   % [s]  average respiratory
 time interval (NOTE: made a bit longer to better illustrate with this
 TR)
physio.respiratory.sigma       = 0.25;  % [s]  the standard deviation
 of "
physio.respiratory.A_z         = 1.0;   % [cm] average chest motion
 height
physio.respiratory.A_z_sigma   = 0.005; % [cm] the standard deviation
 of chest motion height
physio.cardiac.TI              = 1.05;  % [s]  heart beat time
 interval
physio.cardiac.IPFM.freqs      = [0.02,0.1,NaN];    % [Hz] frequencies
 for Integral Pulse Frequency Modulation Model (IPFM)
physio.cardiac.IPFM.sigmas     = [0.2,0.2,NaN];     % variation of
 rates in terms of fractional value of (1/f) for IPFM
physio.cardiac.IPFM.amplitudes = [1.0, 1.0, (2/3)]; % the sinusoid
 amplitudes  for IPFM
physio.cardiac.IPFM.seeds      = [[s+4*Nt,s+6*Nt], [s+8*Nt,s+10*Nt],
 NaN]; % the random number generator seeds for IPFM
physio.cardiac.PWV.seed        = s+12*Nt;  % the random number
 generator seed for the PWV simulator
% Reference (tSNR model): G. Krüger & G. H. Glover,
%                         "Physiological noise in oxygenation-
sensitive magnetic resonance imaging"
%                         Magn Reson Med. 2001 Oct;46(4):631-7.

[physio_4D,~,~] =
 STANCE_physio_4D(fn_fuzzy_reslice,length(exp_design.Data),scan,physio);

% EPI timeseries, with physiological noise (just sigmas, no lags
% included), no system (thermal)  or attenuation
scan.noise            = 0.0;    % percent noise relative to peak

% save all of the elements common to the session's scan
cd(STANCE_genpath(Now_sss))
save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits','exp_design','physio
cd(STANCEroot)

[~,Y_EPI4D] = STANCE_EPI_signal(fn_fuzzy_reslice,T2star_4D,scan,
[],physio_4D);
```

```
h_EPIp = figure;
plot(Times,squeeze(Y_EPI4D(20,32,38,:)),Times,squeeze(Y_EPI4D(20,32,37,:)),Times,s
title('EPI w/ physiological noise: slices 38-34 near peak activation')
xlabel('time (s)')
ylabel('signal intensity')
axis([0 Times(end) 190 220])
lgdn = legend('38','37','36','35','34','Location','best');
title(lgdn,'Slice #')
movegui(h_EPIp,'northeast');

% EPI timeseries, with physiological noise (just sigmas, no lags
% included), and system (thermal) noise (no attenuation)

Now_sss = [4 1 6];
STANCE_new_session(4,1,6,true);

scan.noise            = 1.5;    % percent noise relative to peak

% save all of the elements common to the session's scan
cd(STANCE_genpath(Now_sss))
save('STANCEscan.mat','scan','fn_fuzzy_reslice','sliceLimits','exp_design','noiseM
cd(STANCEroot)

[V_EPI4D,Y_EPI4D] =
 STANCE_EPI_signal(fn_fuzzy_reslice,T2star_4D,scan,noiseMap,physio_4D,
[],[],[],s+2*Nt);

h_EPIalln = figure;
plot(Times,squeeze(Y_EPI4D(20,32,38,:)),Times,squeeze(Y_EPI4D(20,32,37,:)),Times,s
title('EPI w/ all noise: slices 38-34 near peak activation')
xlabel('time (s)')
ylabel('signal intensity')
axis([0 Times(end) 165 240])
lgdn = legend('38','37','36','35','34','Location','best');
movegui(h_EPIalln,'south');

clear task;

Adding physiological noise to the times-series ...
Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session005.
o Generating the respiratory volume time-series (RVT).
o Generating the respiratory pulse (RP) time-series.
o Generating the respiratory response (RR) time-series.
o Applying the respiratory response function to time-series.
o Generating the VLF heart-rate modulation time-series.
o Generating Mayer wave blood pressure (BP) variation time-series.
o Generating the instantaneous heart rate (HR) time-series from a
 generalized IPFM model.
o Generating the cardiac response (CR) time-series from HR.
o Applying the cardiac response function to time-series.
o Generating the cardiac event impulse (CEI) time-series.
o Generating the pulse wave velocity (PWV) time-series.
o Generating the cardiac pulse (CP) time-series.
```

o Generating the interaction of the cardiac and respiratory pulses (InterCRP) time-series.
o Generating the physiological noise per tissue type time-series.
o Writing C:\spm\STANCE/fMRI/study004/subject0001/session005\EPI_BOLD_0001_005.nii
The maximum intensity of the simulated signal: 254.0037
Erasing files in C:\spm\STANCE/fMRI/study004/subject0001/session006.
o Writing C:\spm\STANCE/fMRI/study004/subject0001/session006\EPI_BOLD_0001_006.nii
The maximum intensity of the simulated signal: 372.9679






```
else
    save('simulations.mat','simulations')
end
cd(currentDir)
```

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