# **Matlab for Neuroscientist 1:**
# Analysing E-prime output with Matlab

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# Contents

- Set path
- Variables and basic operations
- Useful built-in functions
- User-define function
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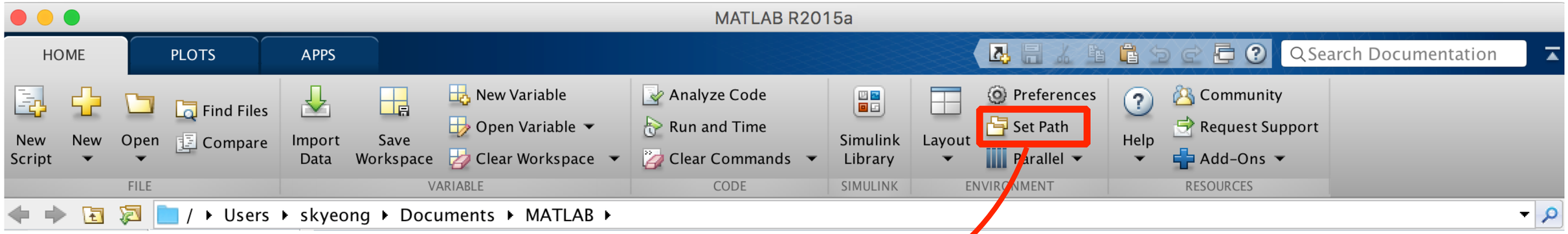
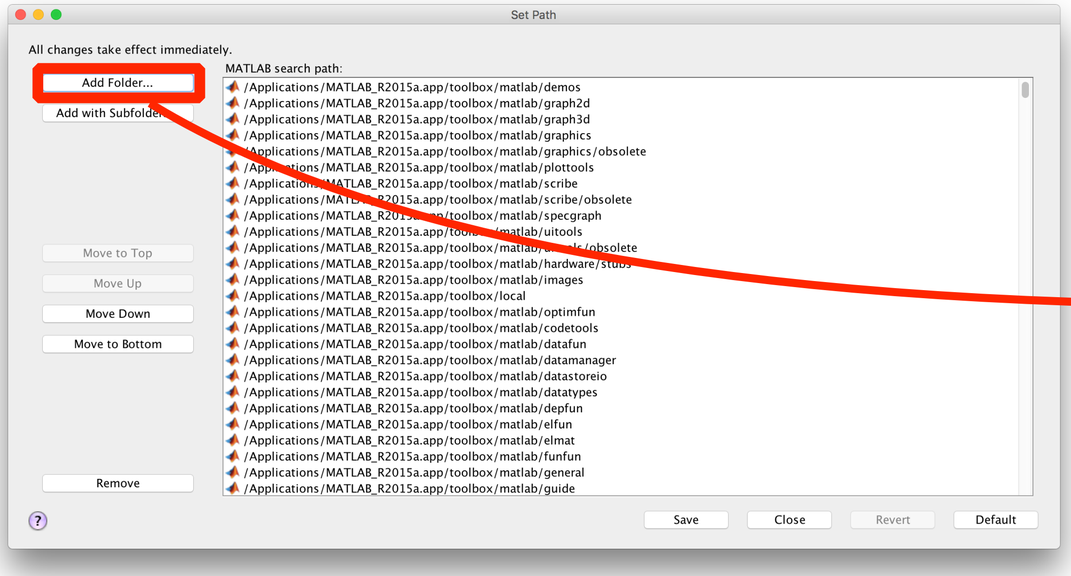
# Set Path to use functions everywhere




Users can add folders, such as SPM12, eeglab, and some other toolbox, to the ‘Path’.
After adding folders to ‘Path’, users can call functions everywhere.

# or in command line,

```
>> addpath('/Users/skyeong/spm12')      % add spm12 folder
>> addpath('/Users/skyeong/eeglab')     % add eeglab folder

>> addpath('C:\spm12')      % add spm12 folder
>> addpath('C:\eeglab')     % add eeglab folder
```

Add path in the commend line works well.
However, you have to type this commend whenever you execute Matlab program.

# Matlab Getting Started

# **help** / to get howto information

```
>> help isfield
   isfield True if field is in structure array.
      isfield(S,FIELD) returns true if the string FIELD is the name of a
      field in the structure array S.

      TF = isfield(S,FIELDNAMES) returns a logical array, TF, the same size
      as the size of the cell array FIELDNAMES.  TF contains true for the
      elements of FIELDNAMES that are the names of fields in the structure
      array S and false otherwise.

      NOTE: TF is false when FIELD or FIELDNAMES are empty.

      Example:
         s = struct('one',1,'two',2);
         fields = isfield(s,{'two','pi','One',3.14})

      See also getfield, setfield, fieldnames, orderfields, rmfield,
      isstruct, struct.

      Other functions named isfield

      Reference page in Help browser
         doc isfield
```

# what, pwd, cd, which

```
>> what          % show matlab codes in an alphabetic order
   MATLAB Code files in the current folder /Volumes/JetDrive/workshops/
   Matlab/lecture1/codes

   anal_Eprime           ex1                    find_column_number
   compute_eprime_data   ex2
>>
>> pwd                              % show present working directory
   ans =

   /Volumes/JetDrive/workshops/Matlab/lecture1/codes
>>
>> cd('/Users/skyeong/Desktop')    % change directory / mac or linux
>> cd('C:\Documents')              % change directory / windows
>>
>> which pwd                    % locate 'pwd' command
>> which ('spm')                % locate 'spm' command
```

# Variables and basic operations

# Scalars and Vectors

```
>> a = 10;                          % integer
>> b = 10.1;                        % real number
>>
>> A_vec = [a, b, 41];              % row vector for real number
>> B_vec = [1, 2, 10]';             % column vector for real number
>>
>> c = a+b;                         % addition of a and b
>> sum(A_vec)                       % sum of elements in A_vec
>> C_sum = A_vec + B_vec ???        % Matrix dimension must agree
>> C_sum = A_vec + B_vec';          % addition of A_vec and B_vec
>> C_m = A_vec*B_vec;               % matrix multiplication (C_m is a scalar)
>> C_m2 = A_vec.*B_vec'             % multiplication in element by element (C_m2 is a vector)
>> C_d = A_vec./B_vec'              % divide in element by element (C_d is a vector)
```

# Character and Cell

```
>> A = 'I am sunghyon';                          % char
>> B = ['I' 'am' 'sunghyon'];                    % also, char
>> C = ['I' ' am' ' sunghyon'];                  % also, char
>>
>> a = 'I';                                      % char
>> b = 'am';                                     % char
>> c = 'sunghyon';                               % char
>> name = [a, b, c];                             % char
>> name2 = [a, ' ' b, ' ' c];                    % char
>>
>> subjlist = {'jjkim', 'shkyeong','ybshin'};    % cell
>> subjlist{1}                                   % jaejkim is returned / char
>> subjlist{2}                                   % shkyeong is returned / char
```

# Struct (put data)

```
>> subj = struct();                    % initialising struct variable

>> subj(1).name = 'jjkim';             % put name field to the struct
>> subj(1).age = 40;                   % put age field to the struct
>> subj(1).sex = 'Male';               % put sex field to the struct
>> subj(1).position = 'Boss';          % put position field to the struct
>>
>> subj(2).name = 'shkyeong';          % put name field to the struct
>> subj(2).age = 33;                   % put age field to the struct
>> subj(2).sex = 'Male';               % put sex field to the struct
>> subj(2).position = 'Podoc';         % put position field to the struct
>> subj
```

# Struct (get data)

```
>> isfield(subj(1),'name')            % check whether or not subj has name
>> isfield(subj(1),'salary')          % check whether or not subj has salary
>>
>> getfield(subj(1),'name')           % get name of the first subject
>> subj(1).name                       % simple way to get name of subj(1)
>> subj(1).('name')                    % another way to get name of subj(1)
>>
>> getfield(subj(2),'position')       % get name of the first subject
>> subj(2).position                   % simple way to get position
>>
>> names = {subj.name};               % get names as cell variable
>> names = [subj.name];               % ?????? I don't recommend this way
>> positions = {subj.position};       % get positions as cell variable
```

# Matrix and its basic operation

```
>> A_mat = [1,2,3; 3,4,5; 7,8,9];   % 3x3 matrix
>> B_mat = [1,1,1; 2,2,2; 3,3,3];   % 3x3 matrix
>> B_vec = [1;2;3];                 % 3x1 matrix
>> a_mat = [1,1; 2,2; 3,3];         % 3x2 matrix
>>
>> C1 = A_mat + B_mat;              % addition in element by element
>> C2 = A_mat * B_mat;              % matrix multiplication
>> C3 = A_mat .* B_mat;             % element by element multiplication
>>
>> D1 = A_mat * B_vec;              % matrix operation
>> D2 = A_mat .* B_vec;             % error
```

# Useful built-in functions

# fprintf / sprintf

- **fprintf** formats data and displays the results in the targeted file or on the screen.
- **sprintf** formats data and returns the results in a string.

```
>> subjlist = {'jjkim','skyeong','honghong'};        % subjlist / a cell variable
>>
>> fprintf('%d-th subj is %s\n', 1, subjlist{1});   % print results on display
>> fn_nii = sprintf('con_0001_%s.nii',subjlist{1}); % print format string
>>
>> % Writing a formatted output in a file
>> fid = fopen('example.csv','w+');                 % create file open handler.
>> fprintf(fid,'id, subjname, age, position\n');
>> fprintf(fid,'%d, %s, %d, %s\n', 1, subj(1).name, subj(1).age, subj(1).position);
>> fprintf(fid,'%d, %s, %d, %s\n', 2, subj(2).name, subj(2).age, subj(2).position);
>> fclose(fid);                                     % close file open
```

# Continued… / % format

- **%s**: a string
- **%d**: integer / **%03d**: three digits integer (ex. 1 —> 001)
- **%f**: real number
- **%.1f (%.3f)**: real number with 1 (3) decimal(s) expression.

```
>> A = [3, 3, 4];                                  % A vector / size of 1x3
>> fprintf('%d %01d %02d\n', A(1), A(2), A(3));
>> fprintf('%.1f %.2f %.3f\n', A(1), A(2), A(3));
>> fprintf('%d, %d, %d\n', A(1), A(2), A(3));
>> fprintf('%d-%d-%.1f\n', A(1), A(2), A(3));
>> fprintf('%d-%d-%.1f\n', A);                     % simply since A is a vector,
```

# fileparts / fullfile

- **fileparts**(FILE) returns the path, file name, and file name extension for the specified FILE
- **fullfile**(DIR1,DIR2,…, filename) Build full file name from parts.

```
>> fn = '/Users/skyeong/Desktop/example.csv';          % specify file name
>> [p, f, e] = fileparts(fn);                         % path, file name, extension.
>>
>> data_path = '/Users/skyeong/Desktop';              % a char variable
>> fn1 = fullfile(data_path,'con_0001_jaejkim.nii');  % jjkim's con_0001 file path
>> fn2 = fullfile(data_path,'con_0001_skyeong.nii');  % kyeong's con_0001 file path
```

# for, while / loop

- **for** and **while** are used when we want to do the same thing with changing subject. For example, Think about that computing functional connectivity for 100 subjects.

## for-loop

```
>> % count No. of subj
>> nsubj = length(subj);
>>
>> % repeat commands within for-loop
>> for c=1:nsubj,
>>     fprintf('%d, %s.\n',c,subj(c).name);
>> end
```

## while-loop

```
>> % count No. of subj
>> nsubj = length(subj);
>>
>> % repeat commands within for-loop
>> cnt = 1;
>> while 1,
>>     fprintf('%d, %s.\n',cnt,subj(cnt).name);
>>     if cnt==nsubj,
>>         break;
>>     end
>>     cnt = cnt+1;
>> end
```

# matrix operation vs. loop

- Matlab has a great advantage when using matrix operation.
- Let's assume that we have dose and days of drug administration as following:

```
>> dose = [30, 20.1, 40, 22, 50, 10, 22, 23, 30, 21, 40, 44];
>> days = [32, 21, 11, 30, 16, 2, 30, 4, 11, 2, 36, 59];
```

- What is the total amount of drug administration (dose x days) ?

**using for-loop**

```
>> total_amount = zeros(1,12);
>>
>> for i=1:12,
>>     total_amount(i) = dose(i)*days(i);
>> end
```

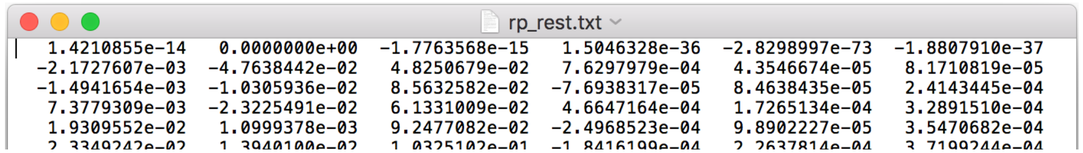
**using matrix operation**

```
>> total_amount2 = dose.*days;
```

Reducing **lines** and computation **times**

# dlmread / dlmwrite

- **dlmread** and **dlmwrite** are used when we want to read and write numeric data (csv-like file but only for numeric data) with a specific separator such as a comma (,), semicolon (;), or tab (\t).




```
>> help dlmread
>> help dlmwrite
```

```
>> DATApath = '/Users/skyeong/Desktop/data';
>>
>> % Load Realignment Parameters
>> fn_motion = fullfile(DATApath,'rp_rest.txt');
>> MOTION = dlmread(fn_motion);
>>
>> % Check size and elements of MOTION
>> size(MOTION)
>> MOTION(:,1:3)      % show first three column
>> MOTION(:,4:end)    % show 4-th column to the last
```

```
>> % Save first three column to the separate file
>> fn_out1 = fullfile(DATApath,'rp_rest_trans.csv');
>> TRANS = MOTION(:,1:3);
>> dlmwrite(fn_out1, TRANS);
>>
>>
>> % Save first three column to the separate file
>> fn_out1 = fullfile(DATApath,'rp_rest_rot.txt');
>> ROT = MOTION(:,4:6);
>> dlmwrite(fn_out1, ROT, 'delimiter','\t');
```

# save / load

- **save** and **load** functions are used when we want to save any kind of variables loaded in Matlab workspace.

```
>> % Save all variables
>> fn_mat = 'mydata.mat';
>> save(fn_mat);
>>
>> % Save specific variables
>> fn_mat2 = 'mydata2.mat';
>> save(fn_mat2,'subj','subjlist');
```

```
>> % Load all data stored in .mat file
>> clear all;
>> load('mydata.mat');
>>
>> % list all variables and its type
>> whos
>>
>> % Load a specific variable
>> clear all;
>> load('mydata.mat','subj');
>>
>> % list all variables and its type
>> whos
```

# figure / plot

## hands-on: **ex1**.m

```
>> DATApath = '/Users/skyeong/Desktop/data';
>>
>> % Load Realignment Parameters
>> fn_motion = fullfile(DATApath,'rp_rest.txt');
>> MOTION = dlmread(fn_motion);
>> size(MOTION);   % Check size of variable
>> scans = 3:152;
>>
>> % Split translation and rotation part
>> TRANS = MOTION(:,1:3);      % in mm
>> ROT = 50*MOTION(:,4:end);   % l=r*theta (r=5cm)

>> % Plot Head Motion - translation
>> figure;
>> plot(scans,TRANS(scans,:));
>> xlabel('Scan number');
>> ylabel('Translation, mm');
>> legend('x','y','z');
```

```
>> % Plot Head Motion - rotation part
>> figure;
>> plot(scans,ROT(scans,:));
>> xlabel('Scan number');
>> ylabel('Rotation, mm');
>> legend('pitch','roll','yaw');

>>
>> % Plot Head Motion - translation part
>> figure;
>> subplot(211); plot(scans,TRANS(scans,:));
>> xlabel('Scan number');
>> ylabel('Translation, mm');
>> legend('x','y','z');
>>
>> % Plot Head Motion - rotation part
>> subplot(212); plot(scans,ROT(scans,:));
>> xlabel('Scan number');
>> ylabel('Rotation, mm');
>> legend('pitch','roll','yaw');
```

# **xlsread** / to read data from excel file

hands-on: **ex2**.m

Excel data:

| subjname | age | sex | position |
|---|---|---|---|
| jjkim | 40 | 1 | Boss |
| skyeong | 33 | 1 | Podoc |
| honghong | 23 | 2 | Student |

```
>> DATApath = '/Users/skyeong/Desktop/data';
>>
>> % Load Excel data
>> fn_xls = fullfile(DATApath,'subjlist.xlsx');
>> [a,b,xlsData] = xlsread(fn_xls);
>>
>>
>> % Separate header and data
>> hdrs = xlsData(1,:);
>> data = xlsData(2:end,:);
>>
>>
>> % Get list of subjname
>> col_subjname = find_column_number(hdrs,'subjname');
>> list_subject = data(:,col_subjname);
```

```
>> % Get list of position
>> col_position = find_column_number(hdrs,'position');
>> list_position = data(:,col_position);
>>
>>
>> % Get list of age
>> col_age = find_column_number(hdrs,'age');
>> list_age = data(:,col_age);
>> list_age = cell2mat(list_age);
>>
>>
>> % Get list of sex
>> col_sex = find_column_number(hdrs,'sex');
>> list_sex = cell2mat(data(:,col_sex));
```

# User-defined function (1)

hands-on: **find_column_number**.m

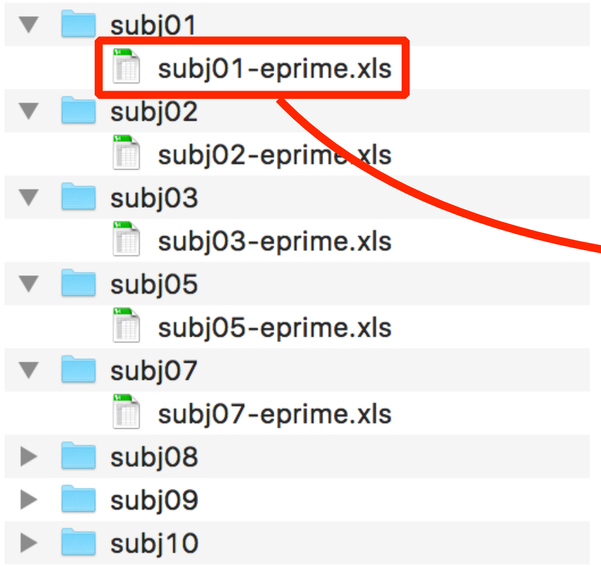
```
function column = find_column_number(list_of_headers,name_of_field)
%FIND_COLUMN_NUMBER is to find the column number from headers
%
%    FIND_COLUMN_NUMBER(list_of_headers, name_of_field) locates the column number
%    of name_of_field.
%
%    list_of_headers - {'name','age','sex','position'};
%    name_of_field   - 'name' or 'position'
%
%    Example:
%      list_of_headers = {'name','age','sex','position'};
%      find_column_number(list_of_headers, 'age');
%      return value would 2 because 'age' is located at the second.

for i=1:length(list_of_headers)
    if strcmpi(list_of_headers{i},name_of_field),
        colnum = i;
        return
    end
end
```

```
>> help strcmpi
>> help find_column_number
```

# Analysing
# E-prime output data with Matlab

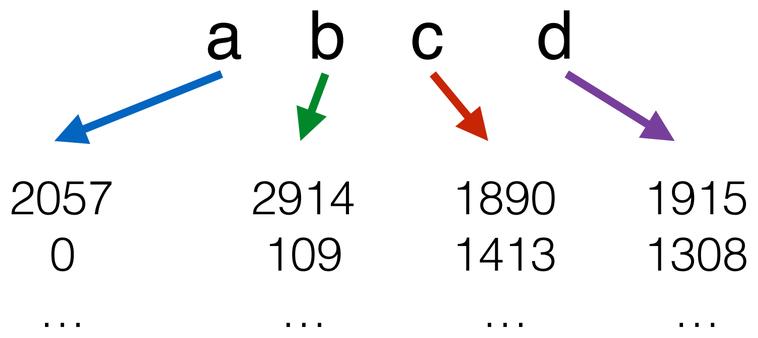
# Work flow…

**E-prime** for each subject




**E-prime** output data looks like…

| ExperimentName | Subject | Session | BRUConfiguration | . . . | Probe.RT | . . . | Stimulus1 |
|---|---|---|---|---|---|---|---|
| JJKIM_Cloth | 1171 | 5 | Unique | | 2057 | | 01a |
| JJKIM_Cloth | 1171 | 5 | Unique | | 2914 | | 01b |
| JJKIM_Cloth | 1171 | 5 | Unique | | 1890 | | 01c |
| JJKIM_Cloth | 1171 | 5 | Unique | | 1915 | | 01d |
| JJKIM_Cloth | 1171 | 5 | Unique | | 0 | | null |
| JJKIM_Cloth | 1171 | 5 | Unique | | 0 | | 02a |
| JJKIM_Cloth | 1171 | 5 | Unique | | 109 | | 02b |
| JJKIM_Cloth | 1171 | 5 | Unique | | 1413 | | 02c |
| JJKIM_Cloth | 1171 | 5 | Unique | | 1308 | | 02d |
| JJKIM_Cloth | 1171 | 5 | Unique | | 0 | | null |




**collect RT data**
for each stimulus type

# anal_Eprime.m (1/3)

```
>> DATApath = '/Users/skyeong/Matlab/lecture1/data';
>>
>> % Load Subject List
>> fn_subjlist = fullfile(DATApath,'subjlist_eprime.xlsx');
>> [a,b,xlsData] = xlsread(fn_subjlist);
>> subjlist = xlsData(2:end,1);
>> nsubj = length(subjlist);  % count the cell element in 'subject' variable
>>
>> % Calculate average RT for each subject and condition
>> RT = struct();
>>
>> for c=1:nsubj,
>>
>>     subjname = subjlist{c};
>>     fprintf('analyzing data for %s.\n',subjname);
>>
>>     % Load Eprime data for each subject
>>     filename = sprintf('%s-eprime.xls',subjname);
>>     fn_xls = fullfile(DATApath,'Eprime',subjname,filename);
>>     [a,b,xlsData] = xlsread(fn_xls);
```

# anal_Eprime.m (2/3)

```
>>
>>      % Spliting headers and data
>>      hdrs = xlsData(1,:);
>>      data = xlsData(2:end,:);
>>
>>      % Get colnum IDs for RunTitle, RESP, RT, and StimType
>>      colnum_RT       = find_column_number(hdrs,'Probe.RT');
>>      colnum_evtType  = find_column_number(hdrs,'Stimulus1');
>>
>>      % Get session information, RESP, RT, evtType
>>      Eprime = struct();
>>      Eprime.RT       = cell2mat(data(:,colnum_RT));
>>      Eprime.evtType  = data(:,colnum_evtType);
>>
>>
```

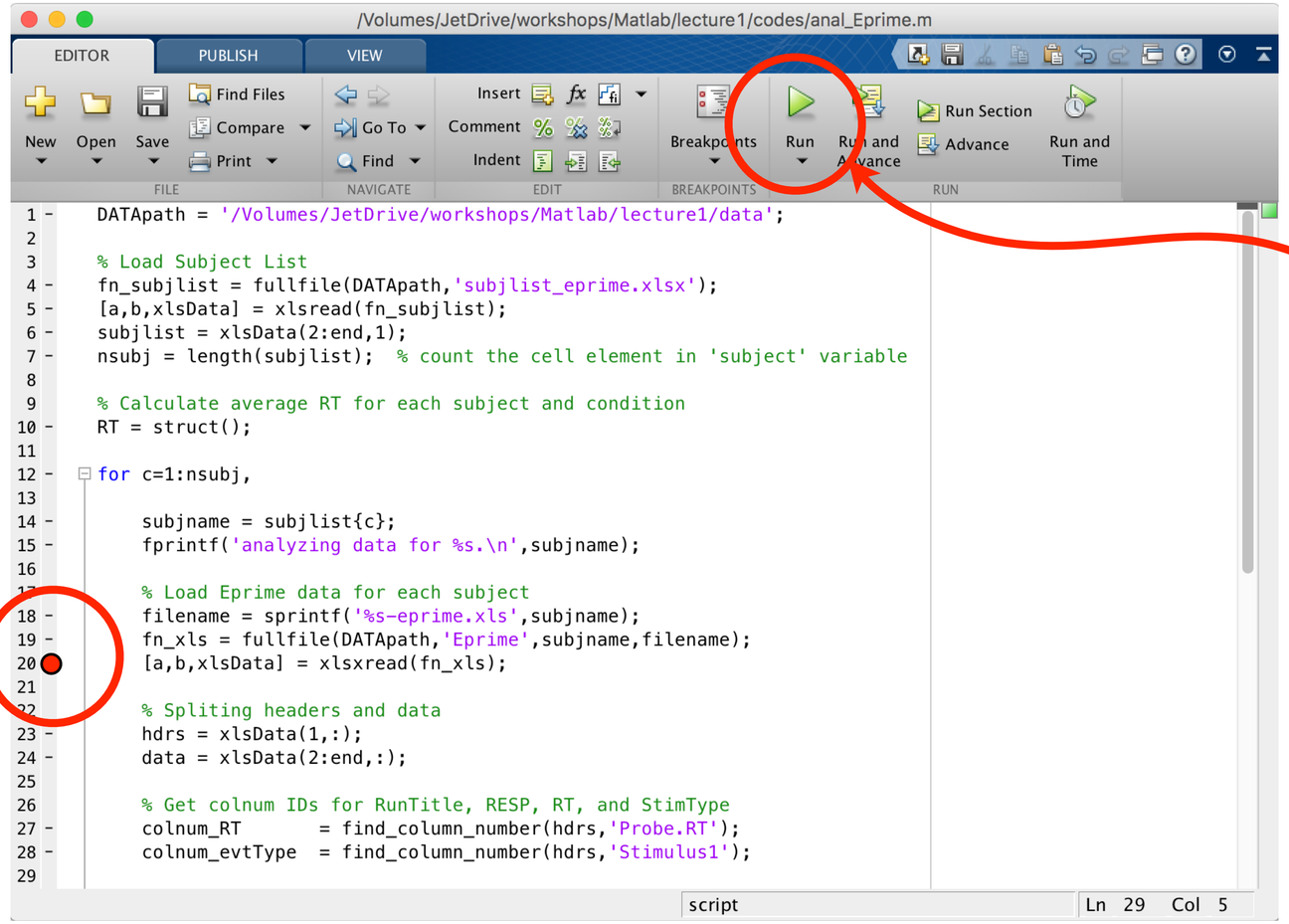
# anal_Eprime.m (3/3)

```
>>  % Catagorizing Eprime data for each condition
>>     RT_subj = compute_eprime_data(Eprime);
>>     evtTypes = fields(RT_subj);
>>     for i=1:length(evtTypes),
>>         evtType = evtTypes{i};
>>         if strcmpi(evtType,'1'), continue; end
>>         RT(c).(evtType)   = mean([RT_subj.(evtType)]);
>>     end
>> end
>>
>>
>> % Write results in a csv-file
>> fn_out = fullfile(DATApath,'anal_eprime.csv');
>> fid    = fopen(fn_out,'w+');
>> fprintf(fid,'subjname,RT.a,RT.b,RT.c,RT.d\n');
>> for c=1:nsubj,
>>     fprintf(fid,'%s,%.1f,%.1f,%.1f,%.1f\n',subjlist{c},RT(c).a,RT(c).b,RT(c).c,RT(c).d);
>> end
>> fclose(fid);
```

# Debugging a Matlab Program

# Set breakpoints at each line

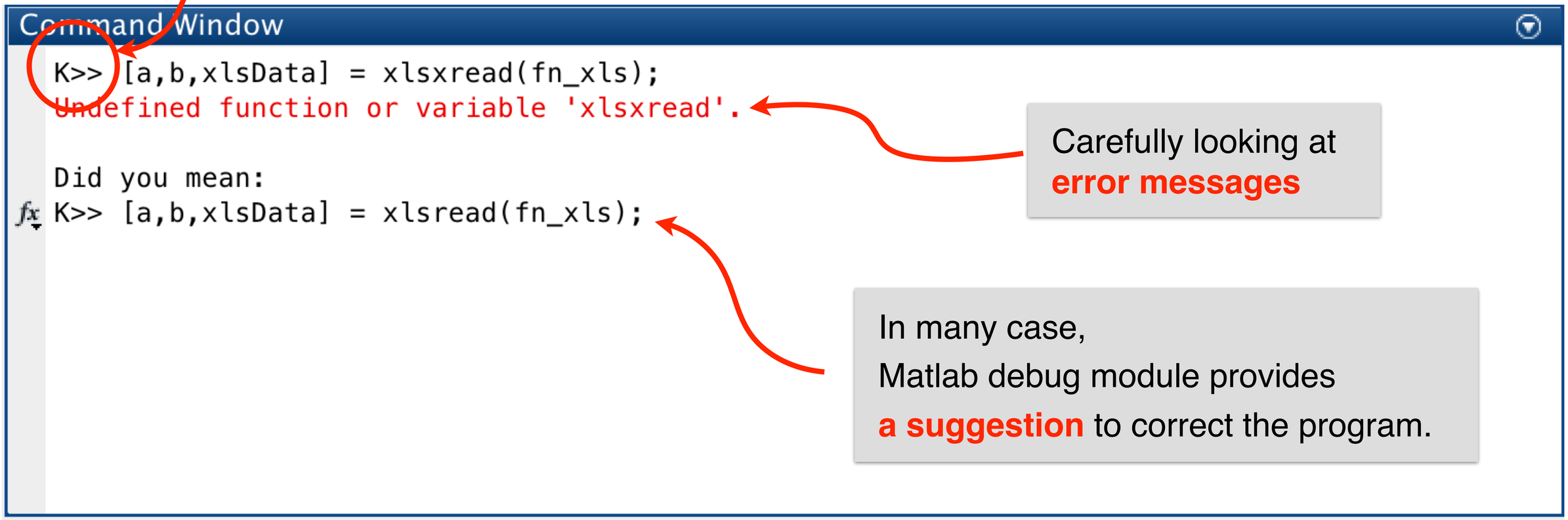
Click here
to set a breakpoint



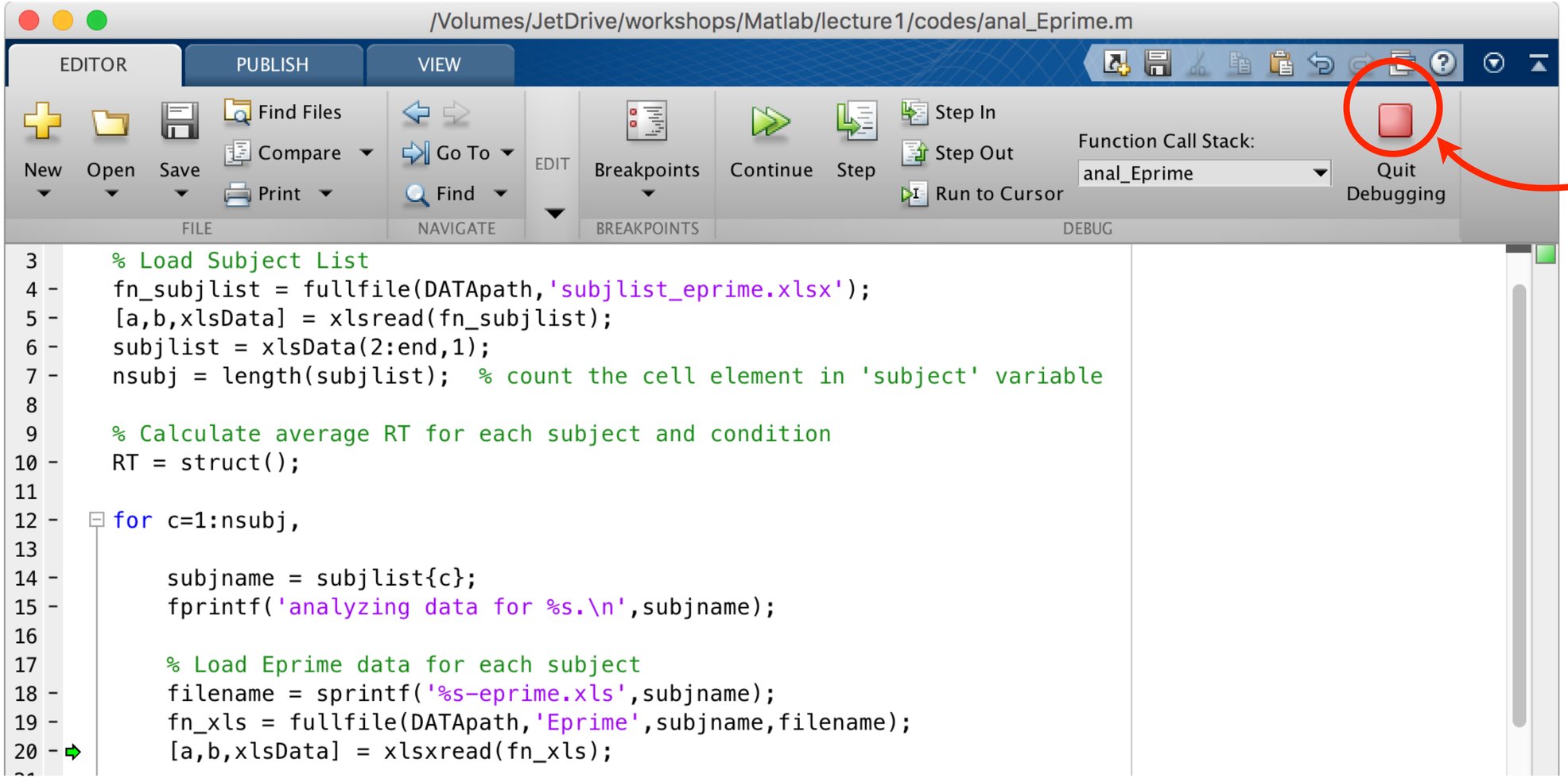

Run
a script

# Debug mode in command window

"**K>>**" indicates that a program is in debug mode



# To escape from a debug mode




Quit debugging