FSCAMDS PROGRAM
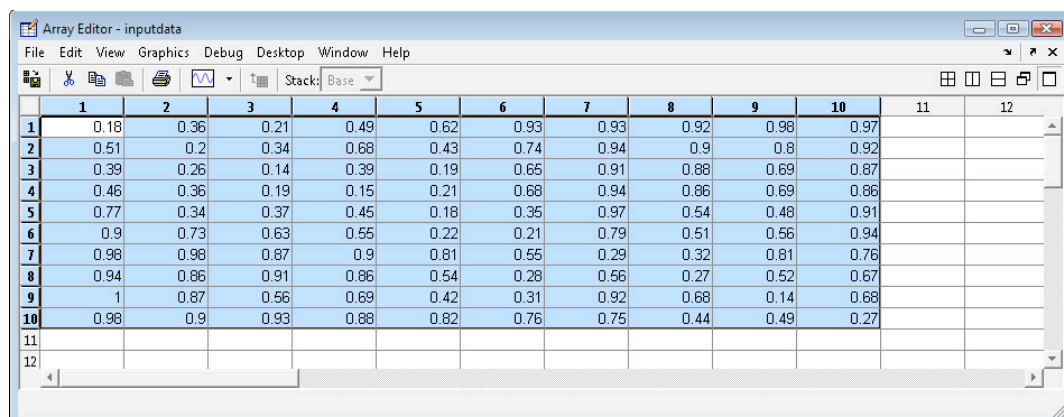# (FSCAMDS stands for Fechnerian Scaling – Clustering – and – Multidimensional Scaling)

Created by Ehtibar Dzhafarov with assistance of Wasin Rujikietgumjorn and Jakkrapun Chuanasa, based on Dzhafarov, E.N., & Colonius, H. (2007, Journal of Mathematical Psychology, 51, 290-304). The posted version is current as of 2010 July 13.

In order to utilize this program, you should have MATLAB (version 7 or later) installed.

The FSCAMDS folder contains this Readme file, the main program FSCAMDS.fig, three sample data sets, and supporting files (which you need not be concerned with). [Sample data sets are 10×10 matrices. In SampleData0.mat Regular Minimality is satisfied in a canonical form, in SampleData1.mat Regular Minimality is satisfied in a non-canonical form, in SampleData2.mat Regular Minimality is violated.]

Data Sets

Data sets, $N \times N$ matrices, should be entered in MATLAB files (.mat) using a function to create new variable (Go to File – New variable). The created variable must be renamed to "inputdata", and then saved as a specific .mat file, e.g. SampleData0.mat. The matrix should be presented as shown in Fig. 1, without labeling of the rows and columns. When you run the FSCAMDS program, the row and column labels will either be entered manually (as described below), or automatically, by default: in the latter case the program will label the rows and columns as a1 (referring to the first row and first column), b1 (referring to the row and column #2), ..., z1 (referring to #26), a2 (to #27), b2 (to #28), ..., z2 (to #52), ..., etc., until the dimensionality of the matrix is exhausted. Thus, in a 10×10 matrix the labeling will be a1, b1, ..., j1; in a 260×260 matrix it will be a1, b1, ..., z1, a2, b2, ...,z2, ..., a10, b10, ..., z10.

Fig. 1

How to Use

1. Open Matlab.

   <u>Note for Mac & Unix users</u>: If you have not used the FSCAMDS program before, or the first time after the FSCAMDS folder has moved to a new location, the path for the FSCAMDS program has to be created. Go to File – Set Path – Add Folder …, browse to locate the FSCAMDS folder, then click Save and Close.

2. Open (using the File menu) the file FSCAMDS.fig. Wait until the program opens and displays the Start window in Fig. 2.

3. Click Start. The program opens the window shown in Fig. 3.

4. Browse for your data file (MATLAB data file), highlight it, and click Open. The name of the file appears in the top window, as shown in Fig. 3.
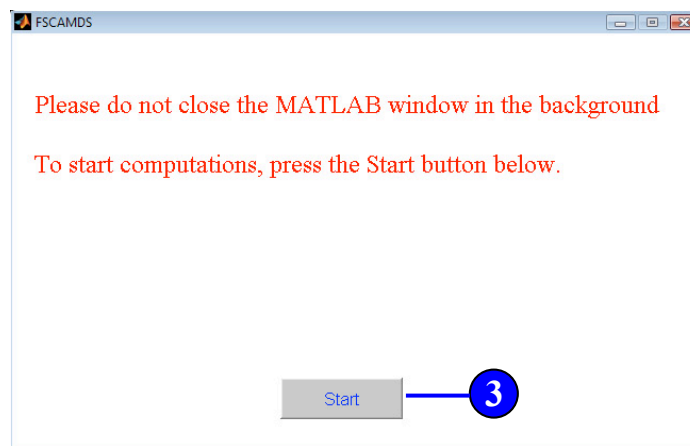

Fig. 2

5. If you do not choose to use your own labels, the rows and columns will be labeled by the default scheme described earlier in Section Data Sets. Otherwise you should enter your labels in the windows shown in Fig. 4, separating the labels by semicolons (one;two;3;four;X). You may put semicolon, comma, dot, or nothing after the last label in either window.

6. Choose checking for Regular Minimality or Regular Maximality (the latter if the data are, e.g., in the Percent 'Same' format).

7. If necessary, you can force regular either in the canonical form (the PSEs on the main diagonal) or by entering PSEs manually. Fig. 5 is a window for inputting PSEs manually. The row labels are separated from column labels by semicolons as shown in Fig.5. Note that the forcing of Regular Minimality only allows for the Long computation.
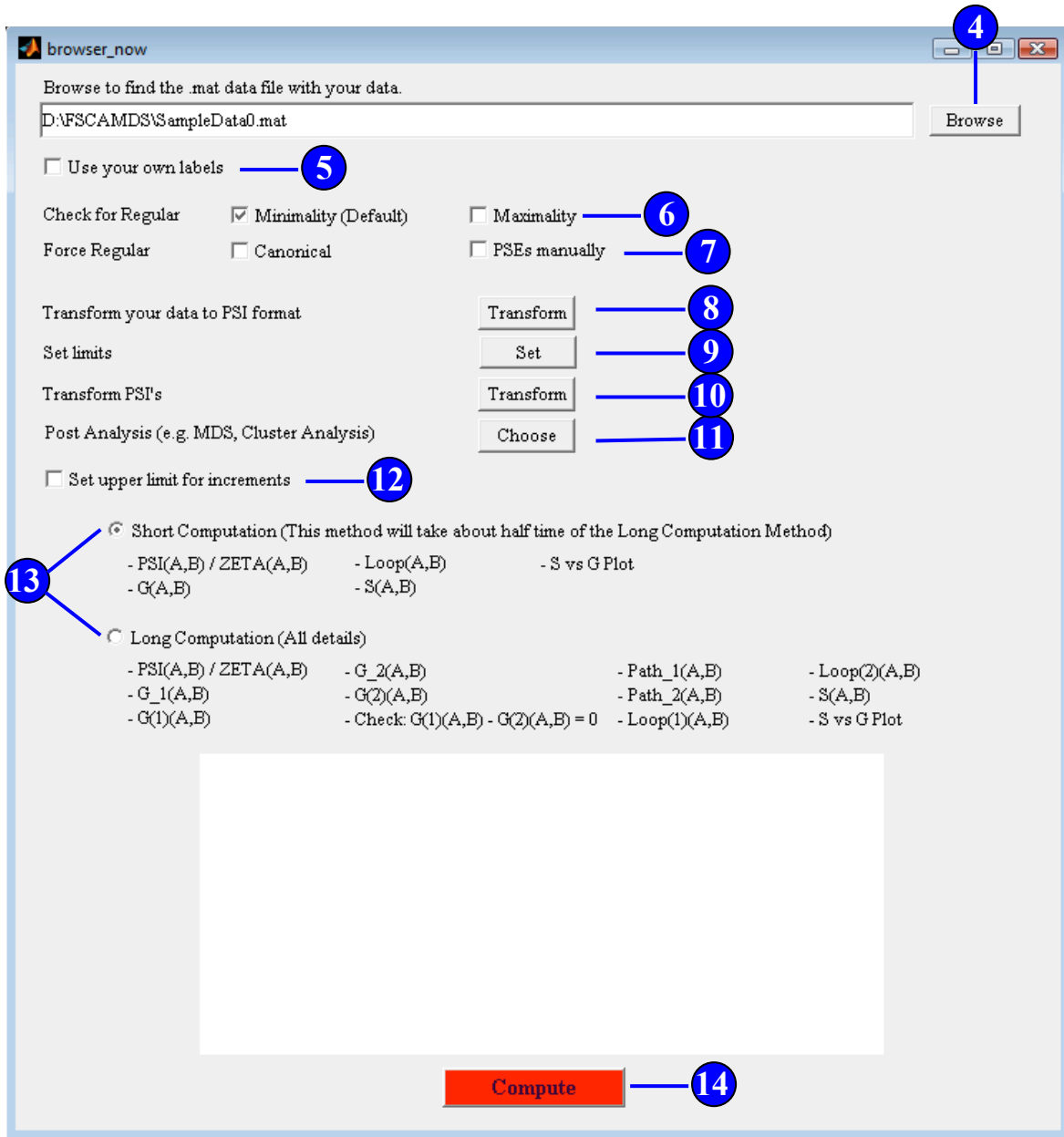
Fig. 3

8. Transform your data to the PSI-format, $\psi(A,B)$ (the format in which the entries are measures of discriminability and subject to Regular Minimality) by using the "calculator" shown in Fig. 6. E.g., if the original data are in the Percent 'Same' format, enter $100 - X$ or $(100 - X)/100$ (X is in the right bottom corner of the main keyboard). If the initial data are already in the $\psi(A,B)$ format, skip this step. In the PSI-matrix the columns are automatically relabeled so that Regular Minimality is satisfied in a canonical form.
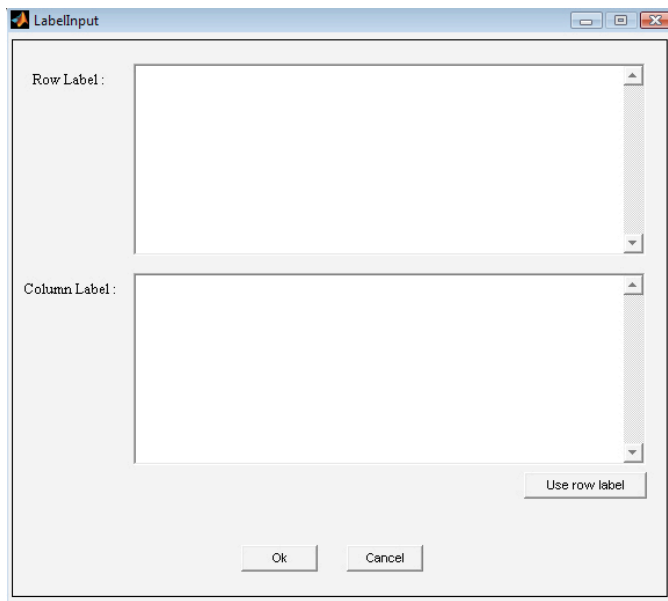
Fig. 4
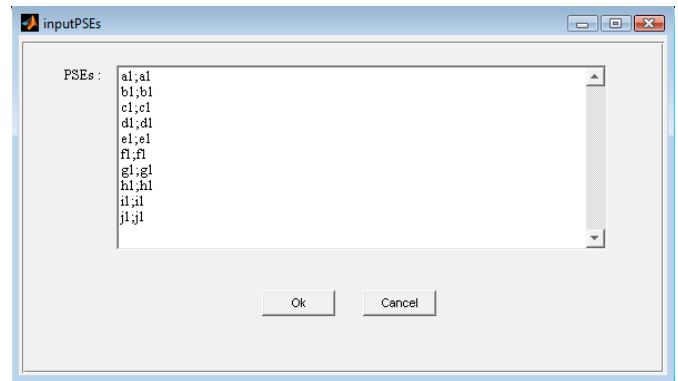
Fig. 5

9. If necessary (otherwise skip), set floor and/or ceiling in your PSI-matrix, as shown in Fig. 7. Any value below the floor is replaced with the floor value; any value above the ceiling is replaced by the ceiling value. Further, you can set an upper limit for $\psi(A,B)$: if a data cell in $\psi(A,B)$ exceeds this limit, it will be labeled Inf and will not be used in the Fechnerian computations (but will be used in the computations of S-indices).

Fig. 6

Fig. 7

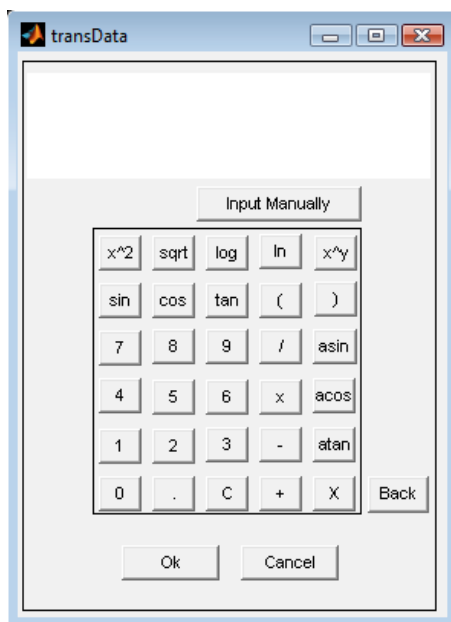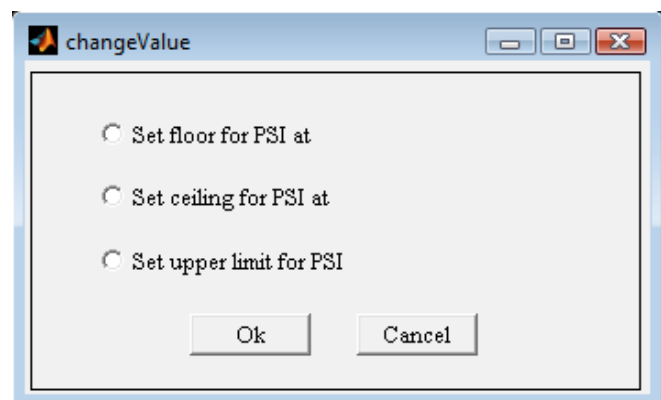10. If necessary (otherwise skip), transform your $\psi(A, B)$ data into a ZETA-matrix by using the "calculator" shown in Fig. 8. For example, type $\log(X/(1-X))$. The transformed entries are denoted $\zeta(A, B)$. If you do not transform the PSI-matrix, then it becomes the ZETA-matrix, $\zeta(A,B) = \psi(A,B)$.
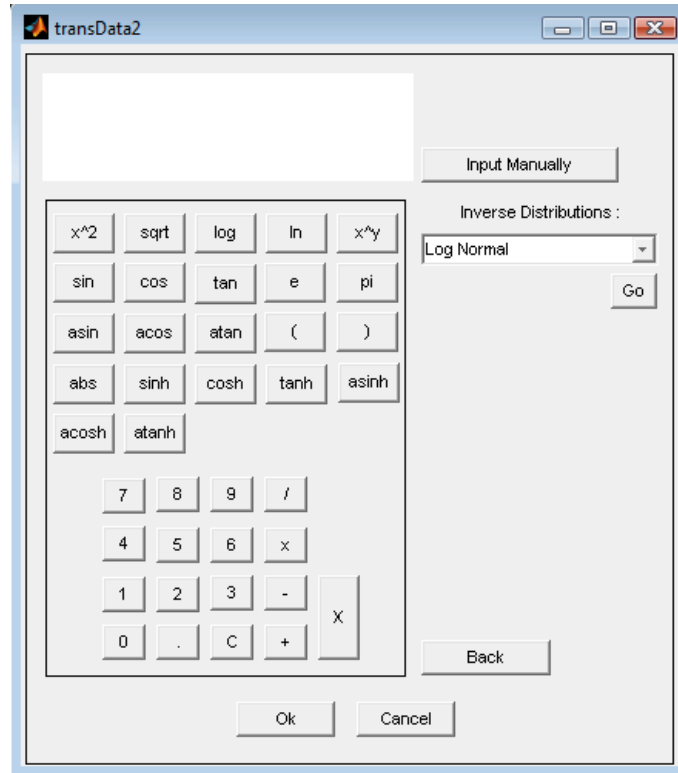
Fig. 8

11. If necessary (otherwise skip), choose "post-Fechnerian" analyses and their options: Multidimensional Scaling (MDS), K-MEANS (only if MDS has been chosen) and/or Hierarchical Cluster Analysis (HCA), as shown in Fig. 9. MDS, metric or nonmetric, will attempt to embed the Fechnerian distances (and, for comparison, the S-indices $\zeta(A, B) + \zeta(B, A) - \zeta(A, A) - \zeta(B, B)$) into a low-dimensional Euclidean space; K-MEANS will cluster the results of this embedding into a designated number of clusters; the HCA will create hierarchical clusters from Fechnerian distances (and, for comparison, S-indices). For

the description of these analyses and the meaning of the options, see MATLAB Help on "mdscale", "kmeans", and "clusterdata".

Fig. 9

12. If necessary (otherwise skip), set an upper limit for the ZETA-increment values $\zeta(A,B) - \zeta(A,A)$, as shown in Fig. 3. If you choose the Long computation (recommended whenever you use upper limits) this will also be the upper limit for) $\zeta(B,A) - \zeta(A,A)$
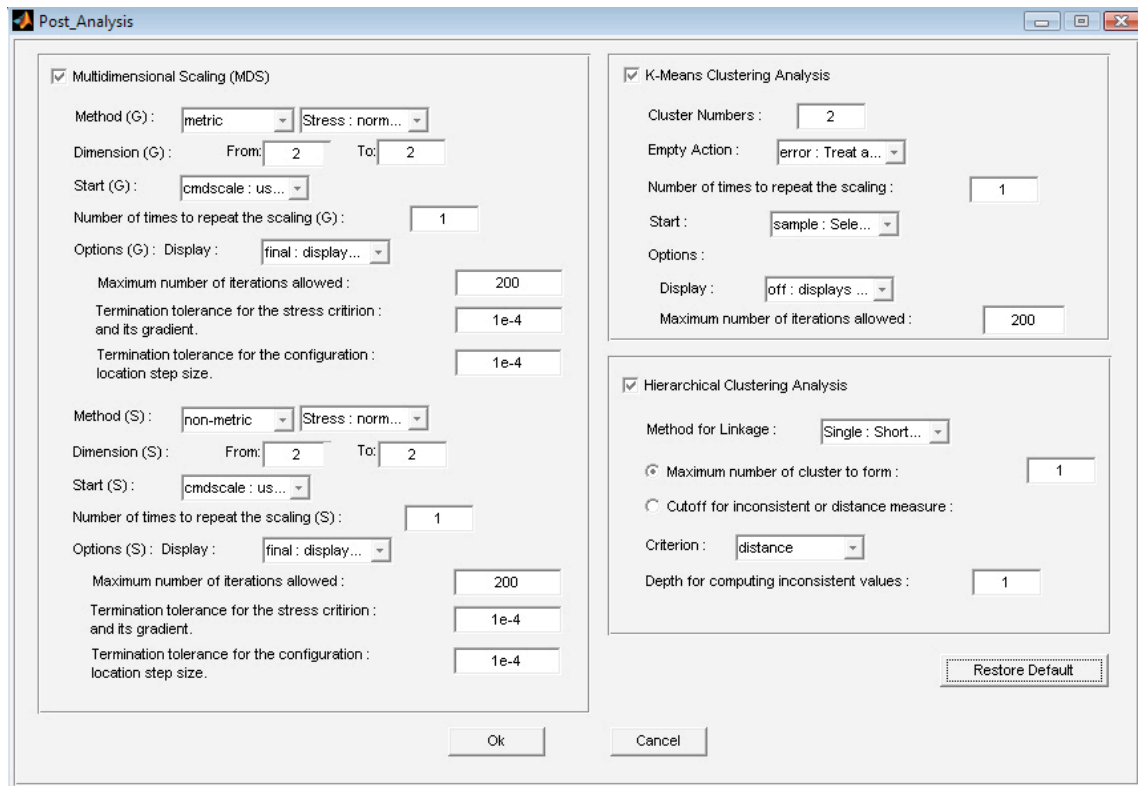
13. Select the type of computations, Short or Long. The Short one yields all main Fechnerian computations, the Long one also yields intermediate results.

14. Click Compute.

15. If Regular Minimality/Maximality in the original data is violated a dialogue box will indicate this with the location of the violation found first, and the computation will stop. If you choose to force Regular Minimality, the program replaces the negative increments with zeros. In this case (as well as when you use upper limits for ZETA-increments) the Fechnerian distances of the first and second kind do not have to coincide. When they do not, the indow shown in Fig. 10 will appear asking you to choose one three options; MAX (of the two Fechnerian distances the program chooses the larger), MEAN (the program averaged

between the two Fechnerian distances), or BOTH (all computations are performed on the Fechnerian distances of the first and second kind separately). If the data are in an inadmissible format, or the PSI-limit set in step 9 is exceeded by a diagonal entry of the PSI-matrix, or if either the PSI-limit or the upper limit for ZETA-increments in step 12 is set so low that some elements cannot be connected by any chains, then the computations will stop with an appropriate error message. Otherwise you will first see the standard work-in-progress

warningCheck

Fechnerian 1 and Fechnerian 2 are different.
Do post-analyses on:

○ MAX ○ MEAN ○ BOTH

Ok   Quit

Fig.10

bar, and then a MATLAB Variable Editor with the resulting tables, as shown in Figs. 11-13, and various plots and graphs, as shown in Figs. 14-18. All these results are saved in a folder named in the same way and placed in the same folder as your data file.

Array Editor - PSI

	1	2	3	4	5	6	7	8	9	10	11	12
1	[]	'A1'	'B1'	'C1'	'D1'	'E1'	'F1'	'G1'	'H1'	'11'	'J1'	
2	'A1'	0.18	0.36	0.21	0.49	0.62	0.93	0.93	0.92	0.98	0.97	
3	'B1'	0.51	0.2	0.34	0.68	0.43	0.74	0.94	0.9	0.8	0.92	
4	'C1'	0.39	0.26	0.14	0.39	0.19	0.65	0.91	0.88	0.69	0.87	
5	'D1'	0.46	0.36	0.19	0.15	0.21	0.68	0.94	0.86	0.69	0.86	
6	'E1'	0.77	0.34	0.37	0.45	0.18	0.35	0.97	0.54	0.48	0.91	
7	'F1'	0.9	0.73	0.63	0.55	0.22	0.21	0.79	0.51	0.56	0.94	
8	'G1'	0.98	0.98	0.87	0.9	0.81	0.55	0.29	0.32	0.81	0.76	
9	'H1'	0.94	0.86	0.91	0.86	0.54	0.28	0.56	0.27	0.52	0.67	
10	'11'	1	0.87	0.56	0.69	0.42	0.31	0.92	0.68	0.14	0.68	
11	'J1'	0.98	0.9	0.93	0.88	0.82	0.76	0.75	0.44	0.49	0.27	
12												
13												

PSE PSI G_matrix Loop S_matrix S_vs_G_Table MDS_Table KMEANS_Table HCA_Table

Fig. 11

Array Editor - G_matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1	[]	'A1'	'B1'	'C1'	'D1'	'E1'	'F1'	'G1'	'H1'	'11'	'J1'	
2	'A1'	0	0.46	0.28	0.57	0.52	0.7	1.22	0.9	1	1.39	
3	'B1'	0.46	0	0.26	0.55	0.35	0.53	0.95	0.73	0.83	1.07	
4	'C1'	0.28	0.26	0	0.29	0.24	0.42	0.94	0.62	0.72	1.11	
5	'D1'	0.57	0.55	0.29	0	0.33	0.51	1.03	0.71	0.81	1.17	
6	'E1'	0.52	0.35	0.24	0.33	0	0.18	0.7	0.38	0.48	0.92	
7	'F1'	0.7	0.53	0.42	0.51	0.18	0	0.62	0.31	0.48	0.88	
8	'G1'	1.22	0.95	0.94	1.03	0.7	0.62	0	0.32	1.03	0.89	
9	'H1'	0.9	0.73	0.62	0.71	0.38	0.31	0.32	0	0.72	0.57	
10	'11'	1	0.83	0.72	0.81	0.48	0.48	1.03	0.72	0	0.76	
11	'J1'	1.39	1.07	1.11	1.17	0.92	0.88	0.89	0.57	0.76		
12												
13												

PSE PSI G_matrix Loop S_matrix S_vs_G_Table MDS_Table KMEANS_Table HCA_Table

Fig. 13

16. The MATLAB results for the Short computation contains the following tables and plots:

The table of PSE (point of subjective equality) pairs and common labels attached to them in the canonical relabeling: e.g., a1 – j3 – A1;

$\psi(A,B)$: presenting the data as measures of discriminability bound to [0,1] and subject to Regular Minimality, with the objects labeled as explained above (A1, B1, etc.);

$\zeta(A,B)$: transformed $\psi(A,B)$, not included in the Variable Editor view initially if you have not used any of the transformations on steps 8-10 so that $\zeta(A,B)=\psi(A,B)$;

$G(A,B)$: the overall Fechnerian distance between A and B (see Fig. 12);

$Loop(A,B)$: a geodesic loop containing A and B (see Fig. 13);

$S(A,B)$: the generalized "Shepardian" dissimilarity (or S-index)

$\zeta(A,B)+\zeta(B,A)-\zeta(A,A)-\zeta(B,B)$;

The plot of $G(A,B)$ vs $S(A,B)$, as shown in Fig. 14; in the corresponding table the correlation is Pearson's, the coefficient C is $2\sum(S-G)^2/\left(\sum S^2+\sum G^2\right)$.
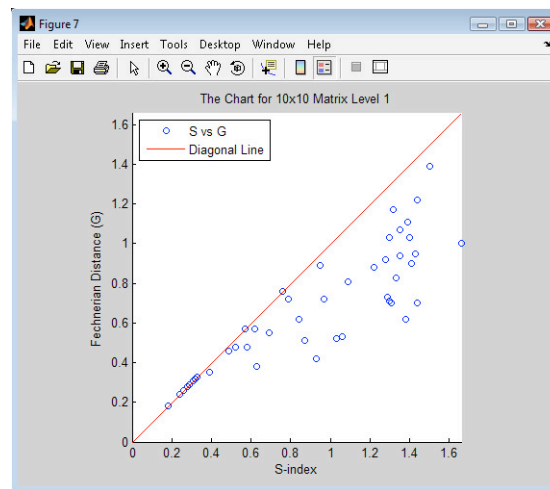
Fig. 14

17. The resulting file for the Long computation contains, in addition, intermediate tables:

$G_1(A, B)$: the oriented Fechnerian distance of the first kind;

$G_2(A, B)$: the oriented Fechnerian distance of the second kind;

$G^{(1)}(A, B)$: the overall Fechnerian distance of the first kind;

$G^{(2)}(A, B)$: the overall Fechnerian distance of the second kind;

"Check" is the check of $G^{(1)}(A, B) = G^{(2)}(A, B)$ (which should hold because the PSI-matrix is in a canonical form);

$Path_1(A, B)$ is a geodesic chain from A to B of the first kind;

$Path_2(A, B)$ is a geodesic chain from A to B in of the second kind;

$Loop^{(1)}(A, B)$ is a geodesic loop of the first kind that contains A and B;

$Loop^{(2)}(A, B)$ is a geodesic loop of the second kind that contains A and B (the same as $Loop^{(1)}(A, B)$ if read in the opposite direction).

18. Finally, the MATLAB plots also present the results of the "post-Fechnerian" analyses, as shown in Fig. 15, 16, 17 and 18. Fig. 16 shows a scree plot of MDS results for the range of dimensions previously chosen by you, as an option shown in Fig. 9. Note that unless you have chosen a single number of dimensions ("from" = "to"), only the scree plot will be shown. whereas the MDS solutions for individual numbers of dimension, as shown in Fig. 15, will be saved in a folder placed in the same folder as your data file). All post-analyses are performed on Fechnerian distances $G(A, B)$ and on S-indices $S(A, B)$.
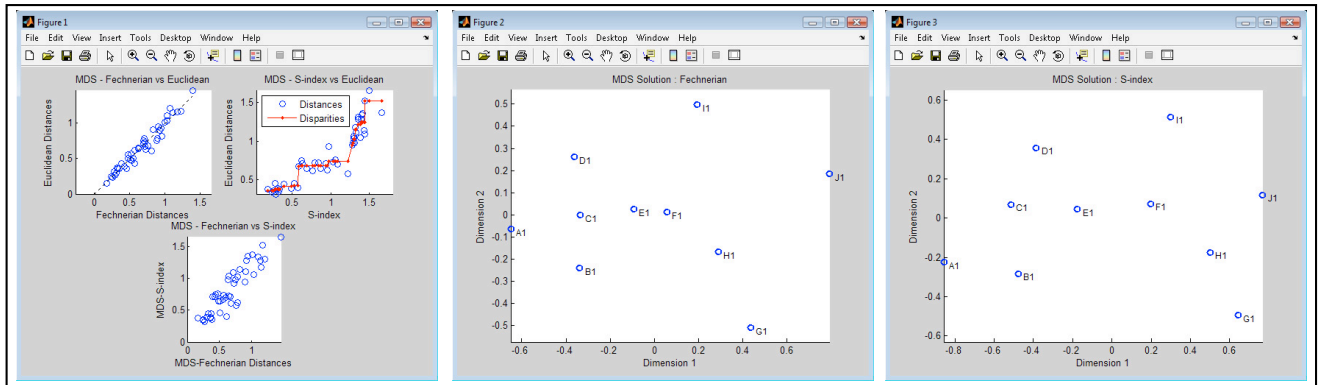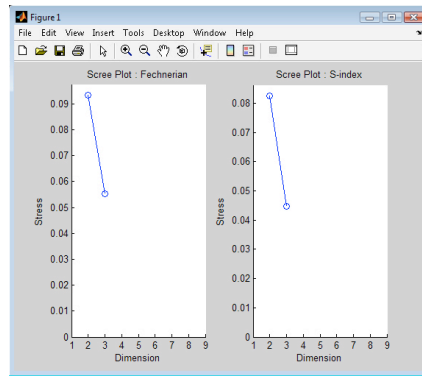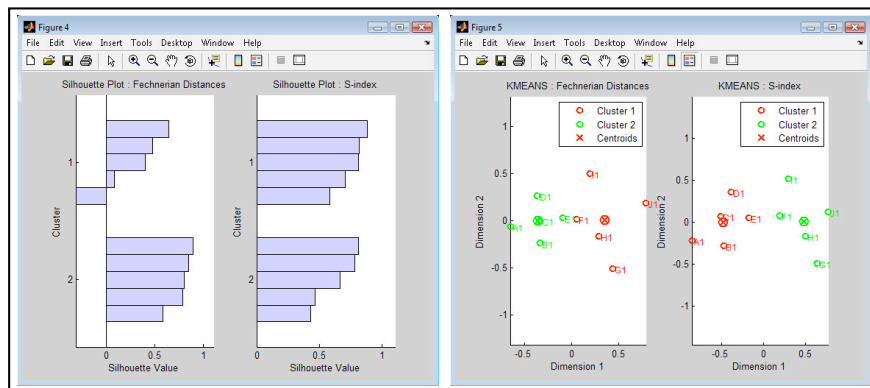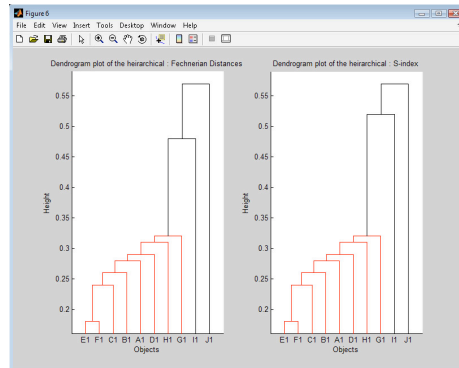

Fig. 15

Fig. 16

Fig. 17

Fig. 18

Saved Results

All the results are saved in a folder named in the same way and placed in the same folder as your data file. Thus, if the latter is X.mat in folder Y, then the results will be saved in folder Y as a subfolder X (or X, X(1), X(2), etc., if X.mat is analyzed repeatedly). The folder of the results contains figure files (*.fig), a table file (Tables.mat), post analysis files (e.g. Output_MDS_Fechnerian and etc.), and a summary text file as shown in Fig. 19.

The plots (.fig file) can be viewed by double-clicking on them. The tables should be opened in MATLAB. The table results are located in workspace window as shown in Fig. 20. You can double click each on them to view in table format.
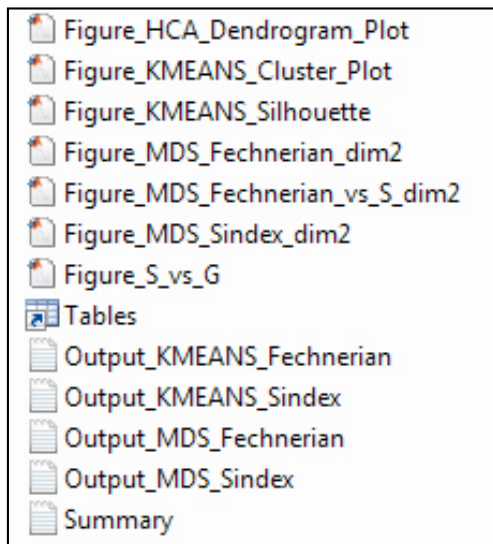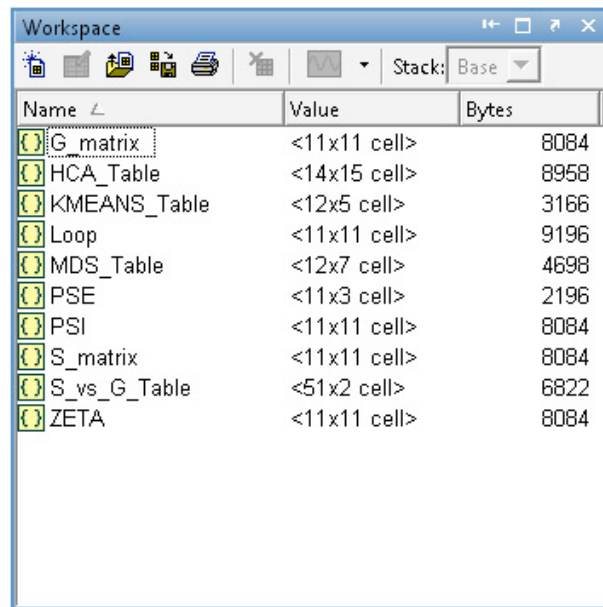
Fig. 19

Fig. 20