Supplementary Materials for *Elliptical Insights: Understanding Statistical Methods through Elliptical Geometry*

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Suppplementary materials: Overview

This document describes the supplementary materials included for this paper. As mentioned in our Discussion (Section 7 of the paper), one goal of this work is to make the links between statistical methods, matrix algebra and geometry explicit. Another goal is make our illustrations statistically and geometrically as nearly exact as possible, and reproducible in standard software (SAS and R). The supplementary materials for these goals are described in Section 1. We also provide some animated movies of 3D graphs, as described in Section 2.

We understand that all of the materials mentioned below will be provided in some form on the publisher's web site. The same materials, in a form that we can update and possibly extend, will be provided at the first author's web site, `http://datavis.ca/papers/ellipses`.

1 SAS and R code for figures

We provide the source code used to generate all of the figures with this supplement in the file `ellipses-suppfiles.zip`. It should be noted that these illustrations were developed over a considerable period of time, using a collection of general SAS macro programs and R packages by the authors and others (listed below). It often happened that these software tools were not sufficiently general or capable for our purposes. In many cases the SAS macros and R packages were extended (or a new package was written, e.g., the **genridge** package (Friendly, 2011, 2012) for the material on ridge trace plots in Section 6.3.1) to make these analyses and figures easier to do in the future. Once we enhanced the SAS macros or R packages, however, we did not often go back and re-do the figures using the revised tools.

1.1 Macros and R packages

The SAS programs use a collection of SAS macros, available from the website `http://datavis.ca/sasmac/`. See `http://datavis.ca/books/sssg/usage.html` for installation and usage notes.

The following R packages beyond those standardly installed with R itself are available from any CRAN mirror site, e.g., `http://cran.us.r-project.org`: **candisc**, **car**, **ellipse**, **heplots**, **mvmeta**, **sfsmisc**. Three other packages, still under development by the authors are available from the R-Forge server, `http://r-forge.r-project.org`: **p3d** (Monette *et al.*, 2011) and **spida** (Monette, 2011); **gellipsoid** implements generalized ellipsoids as described in Appendix A.

1.2 Visual directory for figures

SAS and R source files are contained in the directories SAS/ and R/ respectively. The table below shows thumbnails of the figures together with the name of the corresponding SAS or R source file.
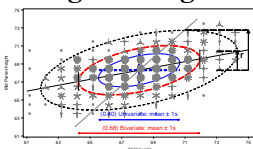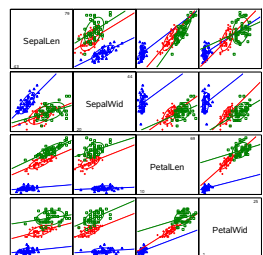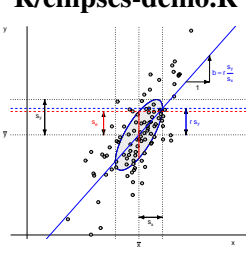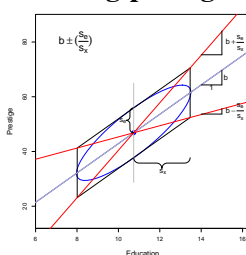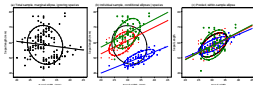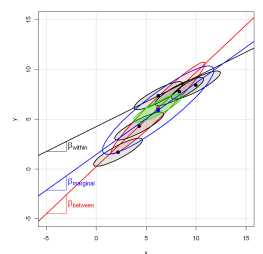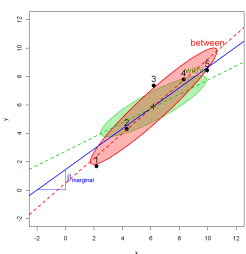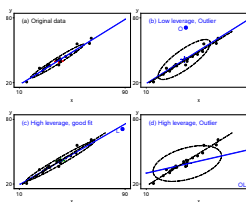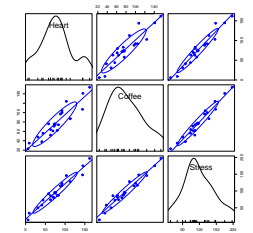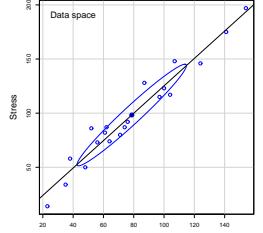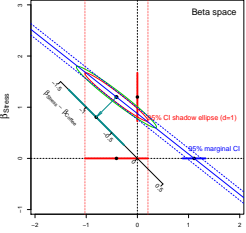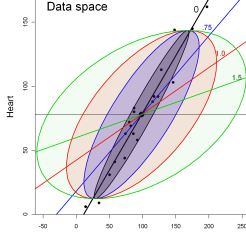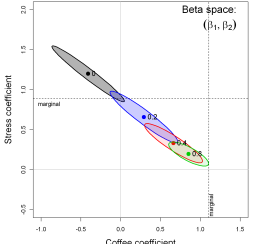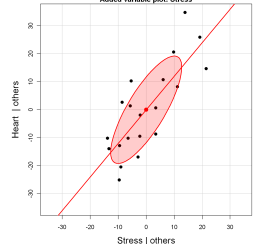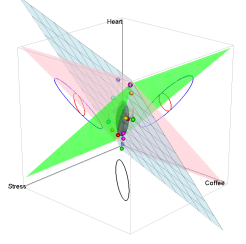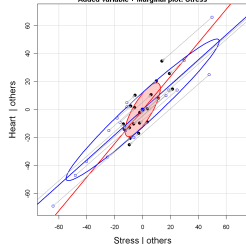
Paper			
Fig. 2 **SAS/galton-reg3.sas** 	**Fig. 3** **SAS/scatirisd.sas** 	**Fig. 4** **R/ellipses-demo.R** 	**Fig. 5** **R/vis-reg-prestige.R**
Fig. 6 **SAS/contiris.sas** 	**Fig. 7** **R/between-within.R** 	**Fig. 8** **R/between-within.R** 	**Fig. 9** **SAS/levdemo2.sas**
Fig. 11 **R/vis-reg-coffee1.R** 	**Fig. 12** **R/vis-reg-coffee1.R** 	**Fig. 13** **R/vis-reg-coffee1.R** 	**Fig. 14** **R/coffee-stress.R**
Fig. 15 **R/coffee-measerr.R** 	**Fig. 16** **R/coffee-avPlots.R** 	**Fig. 17** **R/coffee-av3D.R** 	**Fig. 18** **R/coffee-avPlots.R**
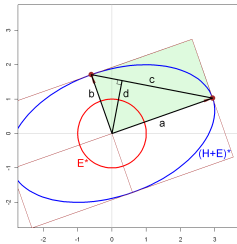
Fig. 19 **R/mtests.R**	Fig. 20 **SAS/heplot3a.sas**	Fig. 21 **R/HE-contrasts-iris.R**	Fig. 22 **R/HE-can-iris.R**
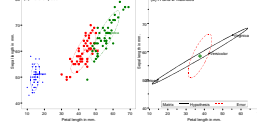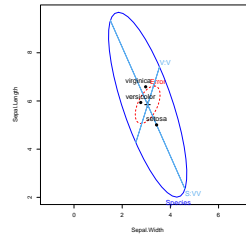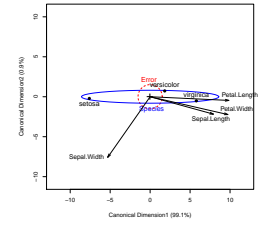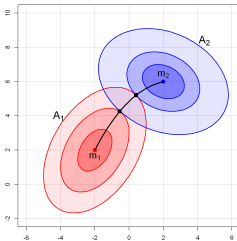
Fig. 23 **R/kiss-demo.R**	Fig. 24 **R/kiss-demo2.R**	Fig. 25 **R/ridge-demo.R**	Fig. 26 **R/ridge2.R**
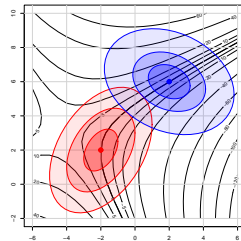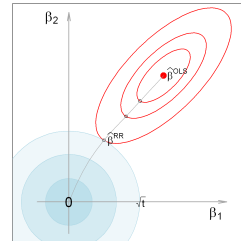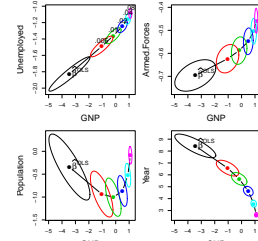
Fig. 27 **SAS/hsbmix4.sas**	Fig. 28 **SAS/hsbmix4.sas**	Fig. 29 **R/mvmeta2.R**
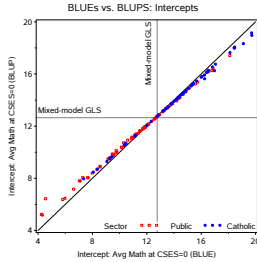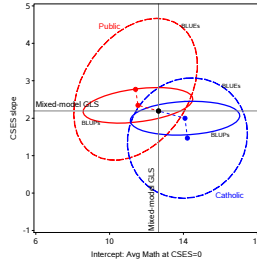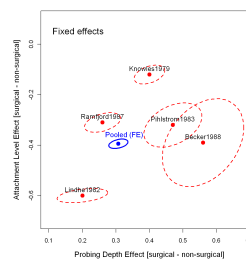
Appendix
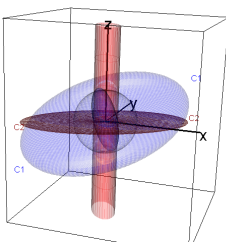
Fig. A.1 **R/gell3d.R**	Fig. A.2 **R/inverse.R**	Fig. A.3 **R/conjugate.R**	Fig. A.4 **R/ellipse-geneig.R**
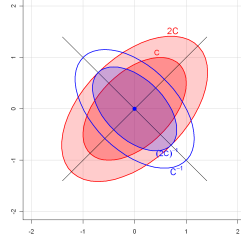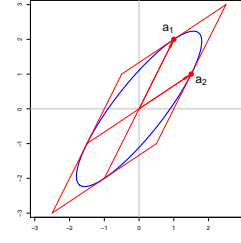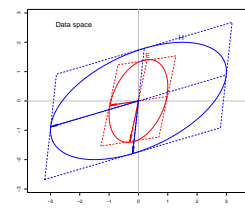
2 Movies

Several 3D figures in the paper or this supplementary Apppendix are rendered as static images from different views in the print version. These figures include Figure 17 and Figure A.1, reproduced below.

These were generated using the **rgl** package in R (Adler and Murdoch, 2011), which allows such 3D views to be rotated, zoomed and otherwise manipulated in 3D space manually, and also supports making animated movies. The movies we created are contained in the movies/ directory.

Figure 2.1: Left: 3D view of the relationship between Heart, Coffee and Stress, from Figure 17 in the paper; source: `R/coffee-av3D.R`. Right: 3D view of an example of generalized ellipsoids, from Figure A.1: source: `R/gell3d.R`.
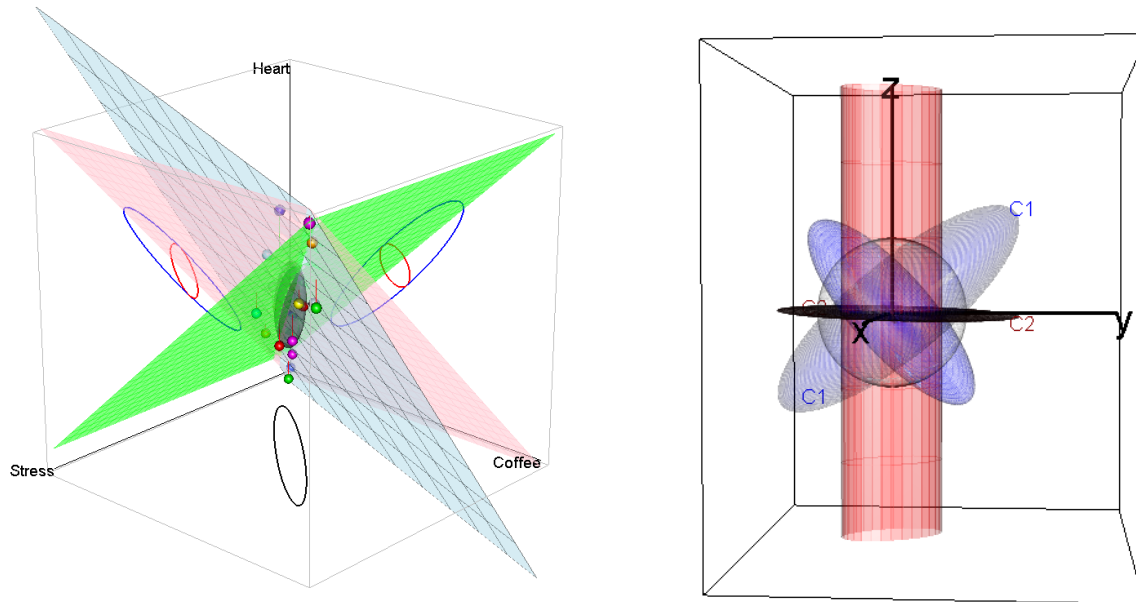
References

Adler, D. and Murdoch, D. (2011). *rgl: 3D visualization device system (OpenGL)*. URL `http://CRAN.R-project.org/package=rgl`. R package version 0.92.798.

Dempster, A. P. (1969). *Elements of Continuous Multivariate Analysis*. Reading, MA: Addison-Wesley.

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Friendly, M. (2012). The generalized ridge trace plot: Visualizing bias and precision. *Journal of Computational and Graphical Statistics*, 21. URL `http://datavis.ca/papers/genridge.pdf`. In press; Accepted, 2/1/2012.

Monette, G. (2011). *spida: Collection of miscellaneous functions for mixed models etc. prepared for SPIDA 2009*. URL `http://R-Forge.R-project.org/projects/spida/`. R package version 0.1-1/r28.

Monette, G., Friendly, M., and Fox, J. (2011). *p3d: Plot 3d data and fitted surfaces*. URL `http://R-Forge.R-project.org/projects/p3d/`. R package version 0.02-4/r31.