

**Essex Summer School**  
**in Social Science Data Analysis and Collection**  
**August 2004**

**Multidimensional Scaling**  
*... why not?*

**Tony Macmillan Coxon,**  
*University of Edinburgh, KU Brussel etc !*



# MDS ... *why not?*

This talk is based on several assertions ...

- ▶ That Research Methodology ( and teaching) adopts a paradigm that is biased (or unhealthily weighted) toward GLM ...
- ▶ **Isn't this paradigm a bit narrow ?**
  - ▶ *A question tagged "understatement" by content analysis,*
  - ▶ *and "Nonne?" by Classicists?*
- ▶ **... and if so, what alternative/s are there?**
  - ▶ within the MDS tradition, primarily.



# MDS ...

## *Some preliminary definitions /elucidations:*

- ▶ **Multidimensional scaling (MDS)**
  - ▶ Family of distance and scalar-product (factor) models. Re-scales a set of dis/similarity data into distances and produces the low-dimensional configuration that generated them
- ▶ **Factor Analysis / Principal Components Analysis (FA/PCA):**
  - ▶ PCA is the full reduction of set of SPs to a new orthogonal set of spanning dimensions (components)
  - ▶ FA is a dimension-reducing model (properly with communalities and not 1 in diagonal) to orthogonal or oblique dimensions (factors)
- ▶ **Correspondence Analysis (CA):**
  - ▶ Reduction of a N (typically 2)-way Table of frequencies or counts to a low-dimensional configuration with points representing categories.
- ▶ **Clustering (CL):**
  - ▶ Family of models representing data as groups or clusters or trees, either a single set or a hierarchy of clusterings. Clusters are usually disjoint (partitions), but also overlapping (+ve) or fuzzy.
- ▶ **Seriation (SER):**
  - ▶ Or Ordination! inferring the sequence (usually temporal) of a set of objects; encompasses also filiation (a tree of descendant objects)



# MDS ...

## Terminology used in this discussion area

- ▶ MultiDimensional Analysis
  - ▶ = MDS + FA/PCA + CA + CL
- ▶ Combinatorial Data Analysis
  - ▶ = CL + SER
- ▶ Dimensional Analysis
  - ▶ = MDS + FA/PCA + CA
    - ▶ And actually, often CL – a dubious inclusion ...



# MDS ...

## Program Series used in this discussion area

### ▲ 2 COMMON PROGRAMS

#### ▲ SPSS

▲ = (some MDS\* + FA/PC + CL + 2WCA) + [Categories: MDS/PROX+(M)CA]

▲ \* Basic MDS program (ALSCAL) is sub-optimal; PROXSCAL only in CATEGORIES ( $\geq$  SPSS10)

#### ▲ NEWMDSX

▲ = MDS + PC + (Hi)CL + CA

▲ PERMAP = interactive MDS, compatible with NewMDSX

▲ HAMLET = text analysis & scaling package compatible with NewMDSX

▲ Good summary of extant programs in Borg & Groenen, Modern Multidimensional Scaling, 2nd edition

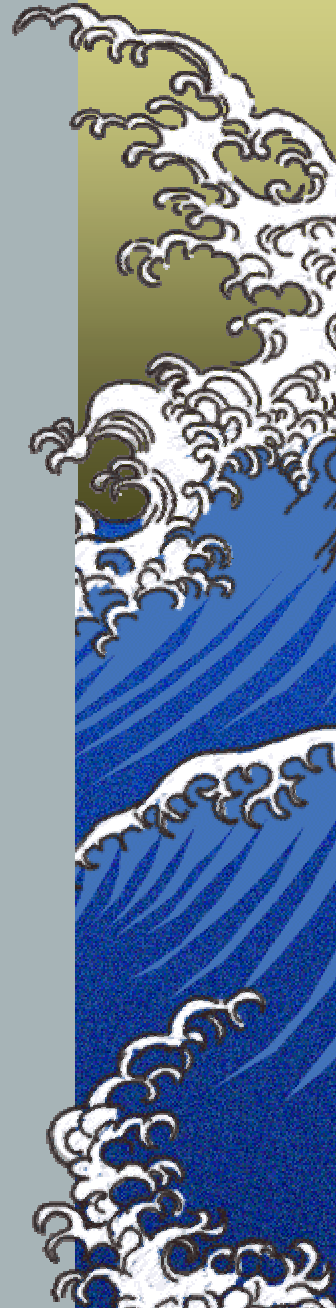


# MDS ... *why not?*

*Now, back to the argument of the talk ...*

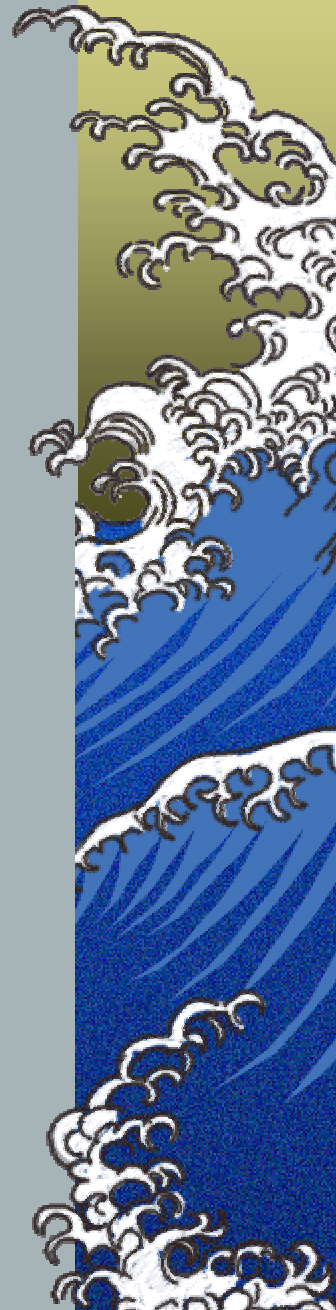
GLM has biases? like what? ...

- ▲ To asymmetric causal reasoning / modelling (aka SEM etc)
- ▲ To quantitative data (perhaps, rather, “numerical” data)
- ▲ to strong measurement assumptions about the data
- ▲ To algebraic thinking, representation and conceptualisation
- ▲ *I'm not saying GLM and MDA are exclusive alternatives*
  - ▲ *Nor am I making a “qualitative vs quantitative” point.*



# MDS ... *why not?*

- ▶ But I *am* arguing that ...
  - ▶ The Causal paradigm is overwhelmingly dominant and restrictive as a methodology,
  - ▶ Multidimensional Analysis is marginalised in teaching and research
    - ▶ Not central (nor sometimes even present) in RM courses, unlike GLM
  - ▶ ... and trivialised ...
    - ▶ “tokenism” of “smallest space analysis” , or “a sort of factor analysis” or “a picture of your data” ...
  - ▶ ... and frankly, is often unknown or misunderstood.



# MDS ... *erm, why?*

## ▲ How does MDS contrast with GLM?

*unlike the GLM* ... MDA

- ▲ Emphasizes symmetric analysis vs causal asymmetry (mostly)
- ▲ Is independent of (pseudo?) quantification (because of the “non-metric breakthrough in mid 1960s)
- ▲ Makes (or can make) conservative (even weak) measurement assumptions about the data
- ▲ Has algebraic specification, but is rooted in geometrical thinking, representation / visualization and conceptualisation





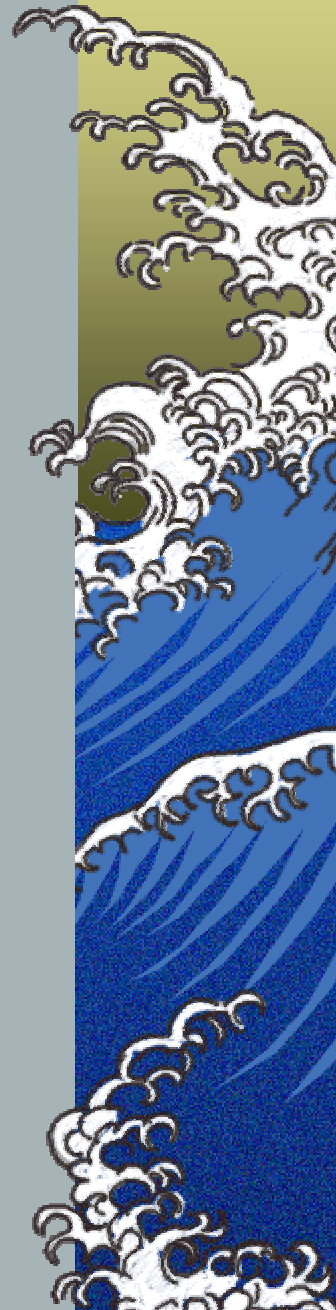
# MDS ... *erm, why?*

- ▶ More positively ... MDA
  - ▶ Is a FAMILY of models (like GLM), which cover:
    - ▶ Cluster Analysis; Correspondence analysis; Factor/PCA; ...
  - ▶ Is FLEXIBLE:
    - ▶ In the level/s of measurement it assumes, & type of model it implements
  - ▶ Is FAR-RANGING
    - ▶ In the types of data it can take – raw and aggregate/measure, Tables, ...
  - ▶ Can be given a common FRAMEWORK
    - ▶ for structuring / understanding the variants of MDS and complexity of models.



# MDS ... frame-work

- ▶ A useful framework for structuring / differentiating / describing ... **D-T-M:**
- ▶ DATA: (input)
  - ▶ primarily in terms of WAY and MODE
  - ▶ Similarity / dissimilarity
  - ▶ “Raw” vs “Derived” (aggregate measure)
- ▶ TRANSFORMATION *aka*
  - ▶ Scaling function;
  - ▶ level of measurement
- ▶ MODEL: (+ Representation)
  - ▶ Originally Euclidean distance



# MDS ... DATA

DATA: (input)

*“anything which can be interpreted as a dis/similarity measure”*

▲ Described primarily by **“Shape”**

▲ Way = dimensionality of data array; Mode = # of sets of distinct elements (mode  $\leq$  way).

▲ E.g. 2W1M = square symmetric measure; 2W2M = rectangular array, 3W2M stack of square matrices....)

▲ **“Raw”** (the data values are scaled directly)

▲ Sortings / Hierarchies / Pair-comparisons / triads /  
Rankings / ratings

▲ **“Aggregate”** (derived as measure from data)

▲ Product-moment measures / Correlations,  
associations, contingencies / Co-occurrence, ID,  
Partition

▲ N-way **Tables** of data



# MDS ... TRANSFORMATION

## TRANSFORMATION (LoM)

### ▲ (Re-) Scaling functions include:

#### ▲ “Non-Metric”:

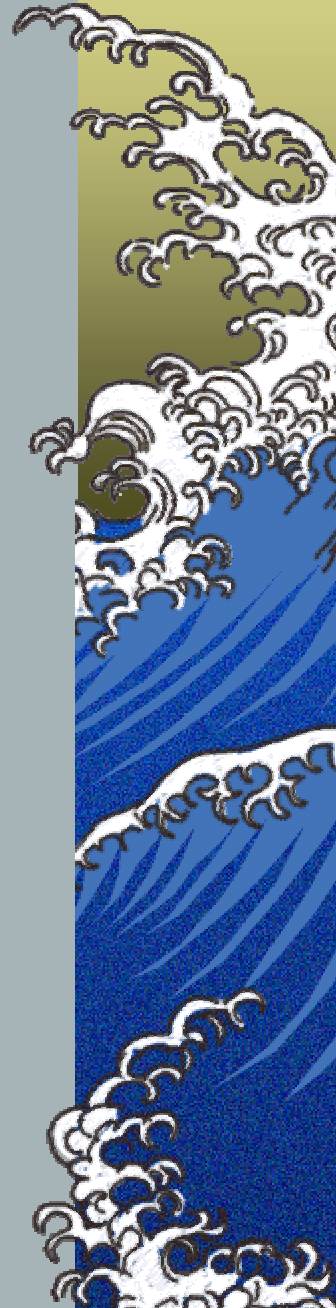
- ▲ Isomenic (category-preserving) (Nominal)
- ▲ (Global/Local; Strong/Weak) Monotone (Ordinal)

#### ▲ “Metric”:

- ▲ Linear
- ▲ Power (inc. MLE power), Log-interval

#### ▲ Other:

- ▲ Spline
- ▲ Continuity (parametric mapping)



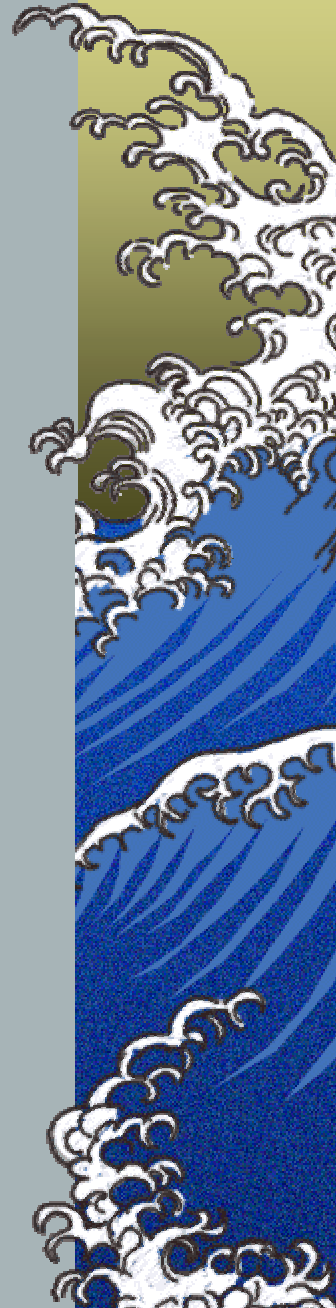
# MDS ... MODEL

## MODEL:

- ▲ Euclidean distance (original)
  - ▲ Euclidean vs other Minkowski Metrics
    - ▲ City-Block ( $r=1$ ); Dominance ( $r=$  📄)
    - ▲ Ultrametric distance (hierarchical clustering)
    - ▲ Buneman's 4-point condition (+ve clustering, trees))
  - ▲ (simple) vs weighted ED (INDSCAL)
- ▲ But also ...
  - ▲ **Scalar-Product** (vector, factor) for the dimensionally-fixated!
  - ▲ Simple Composition or Conjoint Measurement (esp. Additive)

## (+ Representation)

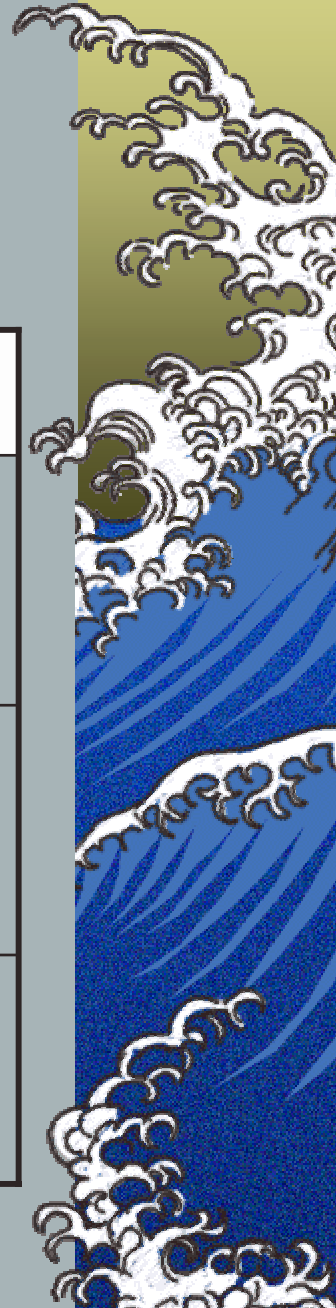
- ▲ **Usually** (low) dimensional real space
  - ▲ Objects as points, or vectors
- ▲ Also discrete representation as tree (or contours in *MDS-why-not?*)



# MDS ... DTM Special Cases

▲ #Dim can be #Clusters, #Ways (Conjt), #Latent Classes (Carroll & Lazarsfeld and Canon.-Decomp)...

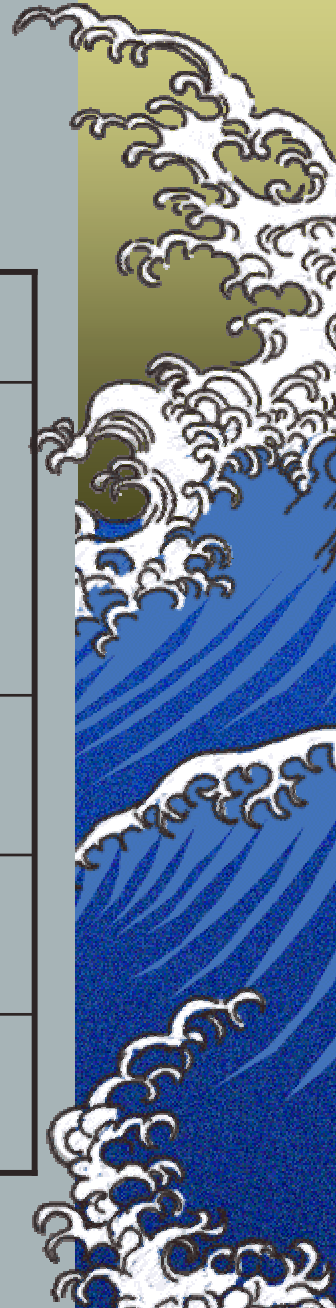
<b>D</b>	<b>T</b>	<b>M</b>	<b>Comment</b>
<i>SP (2W1M )</i>	<i>Lin</i>	<i>SVD</i>	<i>PCA/FA (1)</i>
<i>N-way Table</i>	<i>Lin</i>	<i>R<sup>2</sup> dist</i>	<i>Corresp. Analysis</i>
<i>N-way Table</i>	<i>Mon, Lin.</i>	<i>Compo sition</i>	<i>e.g. Mon-anova, Conjoint</i>



# MDS ... Combinations / Programs

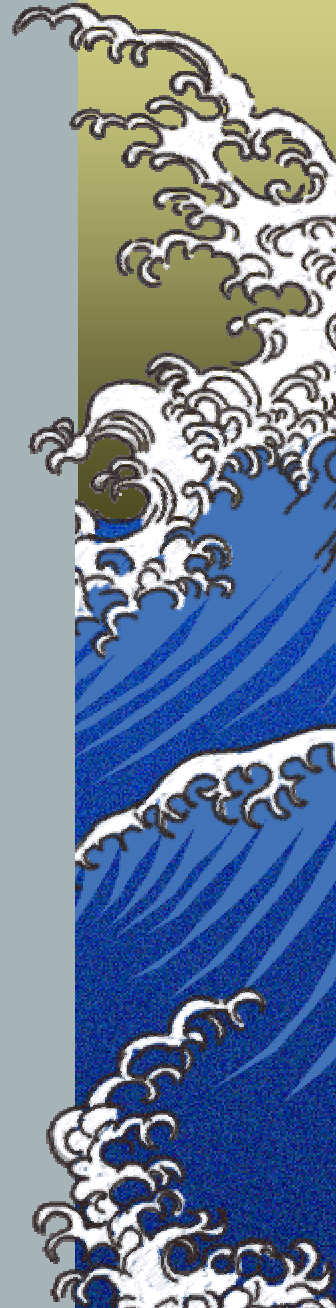
- Combinations of DTM characteristics define programs and options within package- programs . Common ones include:

DATA	TRANS.	MODEL	PROGRAM
2W1M	<i>Mon</i>	<i>Edist</i>	<i>MINI-SSA</i>
	<i>Lin</i>	<i>SP/SVD</i>	<i>PRINCOMP</i>
	<i>Mon</i>	<i>UMdist</i>	<i>HiCLUS</i>
	<i>Lin</i>	<i>Mdist</i>	<i>MRSCAL</i>
2W2M	<i>Mon</i>	<i>EDist</i>	<i>MINI-RSA</i>
	<i>Lin</i>	<i>SP/SVD</i>	<i>MDPREF</i>
(Triads)	<i>Mon</i>	<i>EDist</i>	<i>TRISOSCAL</i>
3W2M	<i>Lin</i>	<i>WDist&amp;SP</i>	<i>INDSCAL</i>



# MDS ... VISUALIZATION

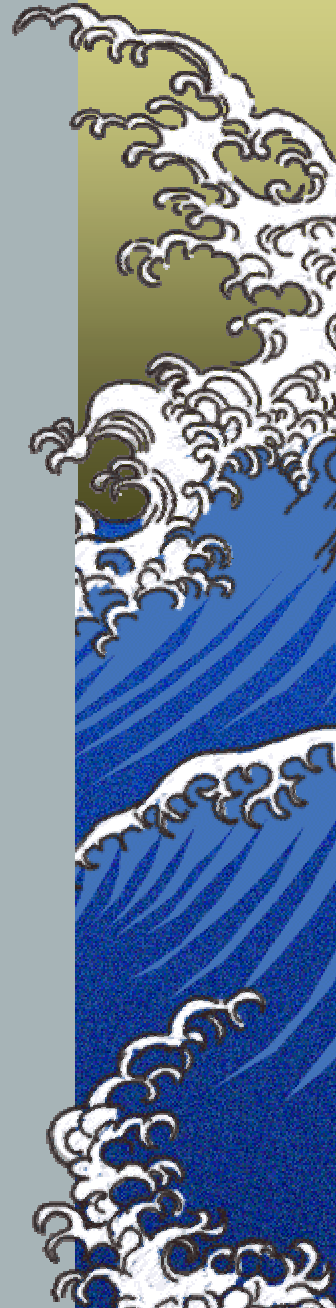
- ▶ *Not only does MDA use visualization, it also requires geometric intuition ... rare!*
  - ▶ *Sociolinguist Bernstein said:*
    - ▶ *"Humans speak. But sociology is silent about that fact". However,*
  - ▶ *Social science methodology also under-estimates that humans use visual thinking that relies on mental graphics systems*
    - ▶ *Statistician Tukey is credited with*
      - ▶ *"a picture is worth a thousand words"*
  - ▶ *But Soc Sc students are by & large ignorant of spatial /geometrical theories of data & analysis*
    - ▶ *E.g. Coombs' Theory of Data; Representational theory of measurement; notions of similarity, distance, points, vectors for representing data*





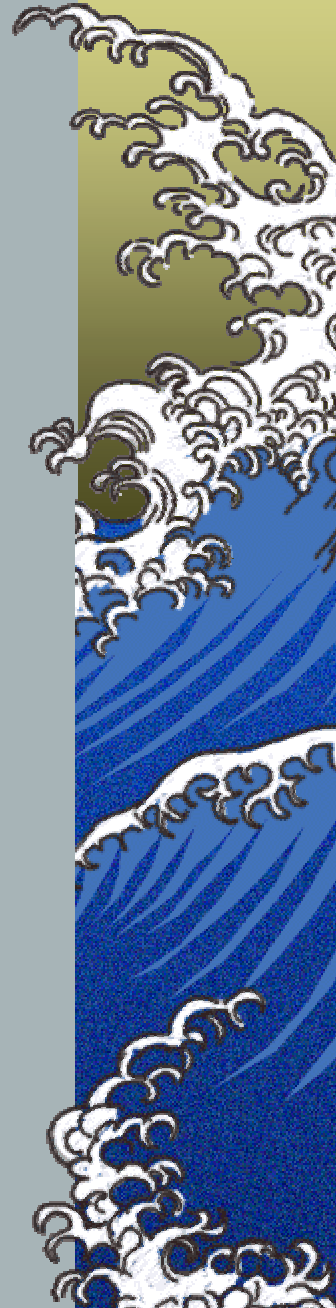
# MDS ... VISUALIZATION

- ▶ Visualization is primarily dependent on the analogy of similarity & proximity (and hence of dissimilarity and distance)
  - ▶ And is enhanced by movement/interaction & colour
- ▶ **Distance is powerful methodology**, and gives excellent training in:
  - ▶ **Visual thinking / cognition**
    - ▶ “ ...uses not language but mental graphics system, with operations that rotate, scan, zoom, pan, displace, fill-in ... (Pinker 1994, p73)
  - ▶ **Interpreting data ( & their analysis & diagnosis) visually**
    - ▶ “it is a mistake to think of a picture as less sophisticated than mathematics ... the eye, the brain and human intuition are the best tools we have for finding patterns” (Levine 1996, p 20)



# MDS ... VISUALIZATION

- ▶ How does MDA ( & esp MDS) do it?
  - ▶ “We buy information by making assumptions” (Coombs), and these are...
    - ▶ Encoded in the assumptions of the model
    - ▶ And also in the level of measurement ... the higher the more demanding and higher the “cost” ...
      - ▶ And MDS (unlike FA) routinely has ordinal variants available, as well as linear
  - ▶ Facilitates multiple conditions/models, and transforms, to allow
    - ▶ a progression of increasingly demanding assumptions,
    - ▶ and the “costs” of assumptions to be assessed
    - ▶ Hence, greater robustness and possibilities of convergent validity.



# MDS ... Illustrations

- ▶ Now, some illustrations, of MDS at work:
  - ▶ Chen's visualization of MDS diagnostics
    - ▶ Using colour and data retrieval to advantage
  - ▶ Run of interactive MDS PERMAP
    - ▶ Heady's freeware program, with visualization of stress-minimization and interactive diagnostics
  - ▶ Graphics within NewMDSX
    - ▶ 2,3 and hi-dimensional plots



# MDS ... Illustrations

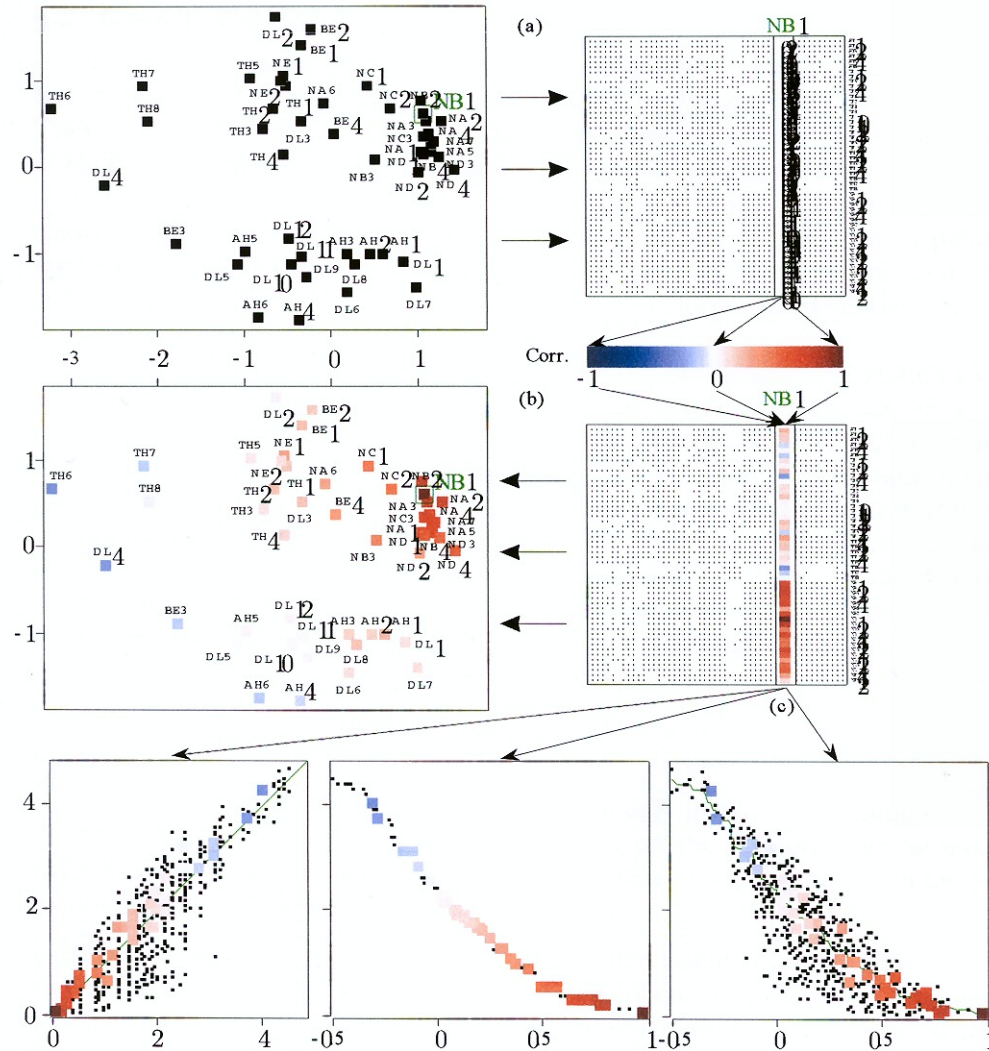
- ▶ *You'll note there's no mention of SPSS;*
- ▶ *why?*
  - ▶ Its main MDS program ALSCAL is sub-optimal
    - ▶ PROXSCAL is OK though
  - ▶ Its graphics are poor; its range of MDS programs is very limited and its documentation is appalling
  - ▶ Still, ... the punters like SPSS, so one has to use it 😞



# MDS ... Chens' visualization of MDS diagnostics

674

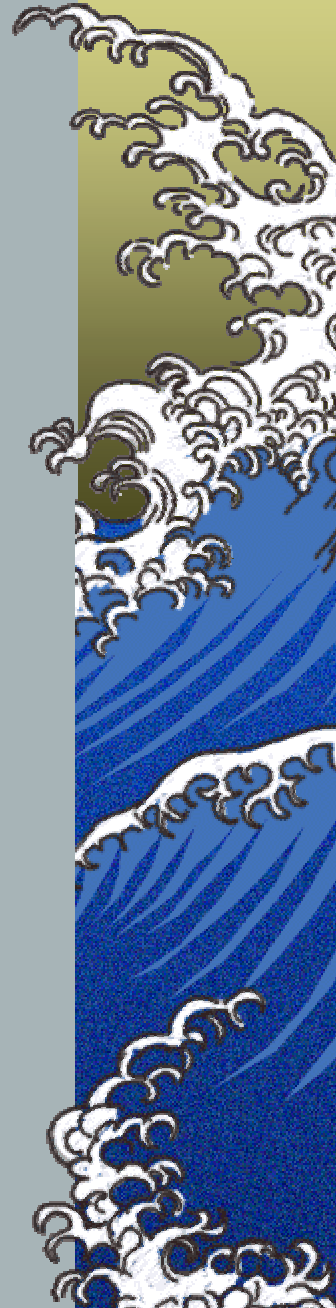
CHUN-HOUH CHEN AND JIH-AN CHEN



# MDS ... Heady's PERMAP

- ▲ Freeware ... get it!  
<http://www.ucs.louisiana.edu/~rbh8900/>
- ▲ Good documentation (Word or WP format)  
<http://www.ucs.louisiana.edu/~rbh8900/PermapManual.pdf>
- ▲ Excellent for **SEEING** importance of local minima and avoiding them
  - ▲ Can be kept running for 1000s of runs, saving lowest stress config.
  - ▲ Flexible re-starts, remove points, change parameters
  - ▲ Diagnostics are excellent
  - ▲ ... but only 2D solution visualised

< *Demo of Drugs data follows* >



# MDS ... Graphics within NewMDSX

## 2,3 and hi-dimensional plots

- ▶ Currently freeware, about to become “non-profit” software [www.newmdsx.com](http://www.newmdsx.com) .
  - ▶ Good documentation (on site)
  - ▶ Library of programs (see handout)
    - ▶ Reliable and optimal algorithms
    - ▶ Enhanced graphics
    - ▶ Real-time runs, but not interactive
    - ▶ Good diagnostics
    - ▶ 2D and 3D are graphic and rotatable etc & Andrews plot for dimensions >3
- < *Demo of Drugs data follows* >

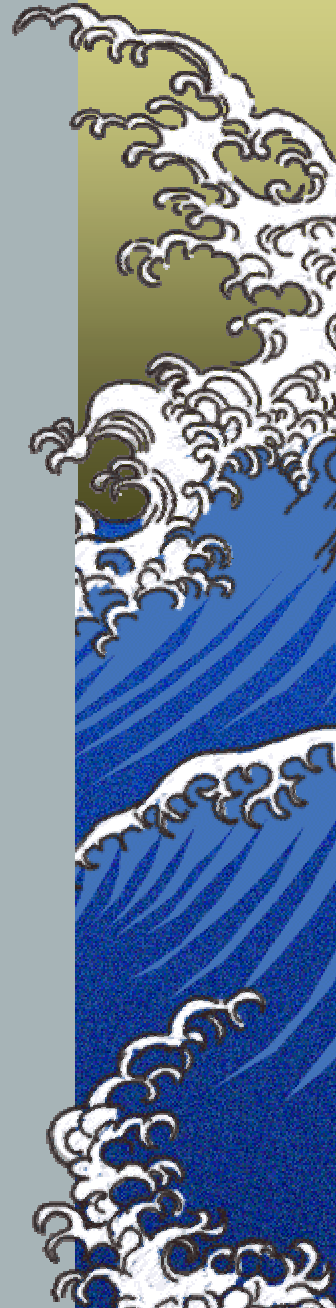




# MDS ...combined with textual analysis

- ▶ Currently freeware: HAMLET  
<http://www.apb.cwc.net/homepage.htm> (download HAMLET)
  - ▶ Compatibility with NewMDSX
- ▶ Contains textual analysis functions including:
  - ▶ KWIC offers Key-Word-In-Context listings for any given word-string
  - ▶ WORDLIST generates lists of words and frequencies
  - ▶ COMPARE lists words common to pairs of texts, useful in generating thematic definitions for number of texts.
- ▶ Generates Jaccard version of co-occurrence as similarity coefficient
- ▶ Includes MDS programs (internally):
  - ▶ MINI-SSA
  - ▶ HICLUS
  - ▶ PINDIS (Prorustes analysis)
- ▶ Enhanced graphics
  - ▶ 2D and 3D are graphic and rotatable etc & Andrews plot

*MDS- why not?*





# MDA ... Some developments

- ▶ **Convergence and mixtures between continuous & discrete models (CDA)**
  - ▶ *Overlapping (Additive) clustering*
    - ▶ *(2W&3W) represented in SSA of same data*
  - ▶ **CLASCAL**
    - ▶ *(INDSCAL but parameterising latent classes not individuals)*
  - ▶ **CORRESPONDENCE ANALYSIS**
    - ▶ *Is there any point in treating separately?!*
- ▶ **Mixed Quantitative-Qualitative**
  - ▶ *Using co-occurrence measure to mediate thematic analysis and MDS & Correspondence Analysis solution/s*
    - ▶ *(HAMLET; T-LAB)*
  - ▶ *Direct scaling of categorical/nominal data (e.g. MD-SORT)*



# MDA ... Some Recommendations

- ▶ MDA should be an integral part of Graduate (& preferably UG) RM syllabus
  - ▶ And distinct from MVA and FA courses
- ▶ Visualization should be an integral part of conceiving data & its/their representation
- ▶ It's actually both instructive, and fun!

