Studying coincidences with network analysis and other statistical tools

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Presentation

Aims

The aims of this presentation are:

- To show *coincidence analysis*, which is a statistical framework to study concurrence of events in large sets of scenarios combining network analysis with multivariate statistics.
- To present coin, an ado program that is able to perform this analysis.
- As an example, an analysis of people in the picture albums of four eminent people in the early 20^{th} century will be presented.
- This analysis has also been applied to
    - Audience figures.
    - Content analysis of media and textbooks.
    - Multiresponse analysis in questionnaires.

Coincidence analysis

Definition

- Coincidence analysis is a set of techniques whose object is to detect which people, subjects, objects, attributes or events tend to appear at the same time in different delimited spaces.
- These delimited spaces are called n scenarios, and are considered as units of analysis (i).
- In each scenario a number of J events X_j may occur (1) or may not (0) occur.
- We call incidence matrix ($\mathbf{X}$) an $n \times J$ matrix composed by 0 and 1, according to the incidence or not of every event $X_{j.}$
- In order to make comparative analysis of coincidences, these scenarios may be classified in H sets

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3 grades of coincidence

Mere and probable events

- Two events (X_j and X_k) are defined as 1) **merely** coincident if they occur in the same scenario at least once:

$$[\exists_i (x_{ij} = 1 \land x_{ik} = 1)] \lor f_{jk} \geq 1$$

- Additionally, two events (X_j and X_k) are defined as 2) **probably** coincident if they occur more frequently than if they are independent:

$$f_{jk} > \frac{f_{jj} f_{kk}}{n}$$

3 grades of coincidence (cont.)

Statistically probable events

- And two coincidences are 3) **statistically probable** if the joint frequency of their events meets one of the following inequalities:

$$\begin{aligned} \mathrm{P}(r_{jk} \leq 0) < c \\ \mathrm{P}(\theta_{jk} \leq 1) < c \\ \mathrm{P}(\mathrm{p}(X_j) - \mathrm{p}(X_j|X_k) \leq 0) < c \end{aligned}$$

  - where r_{jk} is the Haberman residual, θ_{jk} is the odd ratio, and the third equation represents a one tailed Fisher exact test. Furthermore, c is the selected level of significance, normally 0.05)

Adjacencies

Definition for statistically probable events

- Two events j and k can be considered adjacent according to the following rule:

$$A[j, k] = 1 \Leftrightarrow [\mathrm{P}(r_{jk} \leq 0) < c] \wedge j \neq k$$

- Therefore, a $J \times J$ matrix $\mathbf{A}$ may be elaborated with 0 valued diagonal elements and 1 in the case where r_{jk} is significantly below the level c. Other elements should also be 0.
- From $\mathbf{A}$ the $J \times J$ distance matrix $\mathbf{D}$, with geodesics (shortest paths between nodes), can be obtained.

Adjacencies (cont.)

Definition for mere and probable coincidences

- By extension, other adjacency matrices can be elaborated following
  - Mere coincidence criterion

$$A[j,k] = 1 \Leftrightarrow f_{jk} \geq 1$$

  - Or probable coincidence criterion

$$A[j,k] = 1 \Leftrightarrow [\mathrm{P}(r_{jk} \leq 0) < 0.5] \wedge j \neq k$$

Example

4 pictures (scenarios) & 8 different people (events)

Example with names

Father, mother, grandmother and 5 children

Example with codes

Turina, Garzón, Joaquín, María, Concha, José Luis, Obdulia, Valle

Graphical representations of coincidences

Typology

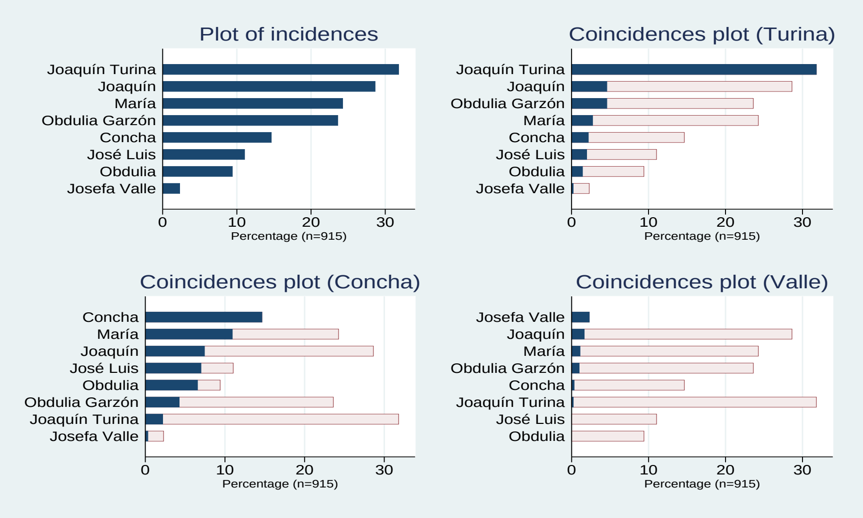
- Bar plots
- Graphs
  - circle
  - mds (multi-dimensional scaling)
  - pca (principal component analysis)
  - ca (correspondence analysis)
  - biplot
- Dendrograms
  - Haberman
  - Geodesic
  - Matching
  - Jaccard
  - Others
  - Single
  - Complete
  - Average
  - Wards
  - Others

Bar plots
Definition

- An incidences plot is the representation of the frequencies of the events that are proportional to the size of their bars.
- A coincidences plot is a composite graph of incidences and coincidences. Every event has its own coincidences plot.

Bar plots of incidences/coincidences

Different patterns of coincidences



Graph

Definition

- "A graph $\mathcal{G}$ consist of two sets of information: a set of Nodes (events), $\mathcal{N} = \{n_1, n_2, ..., n_g\}$, and a set of lines (coincidences), $\mathcal{L} = \{l_1, l_2, ..., l_L\}$ between pair of nodes ". (Wasserman and Faust 1994).
- A non trivial problem is where to draw each node, i.e, the spatial distribution of the nodes.

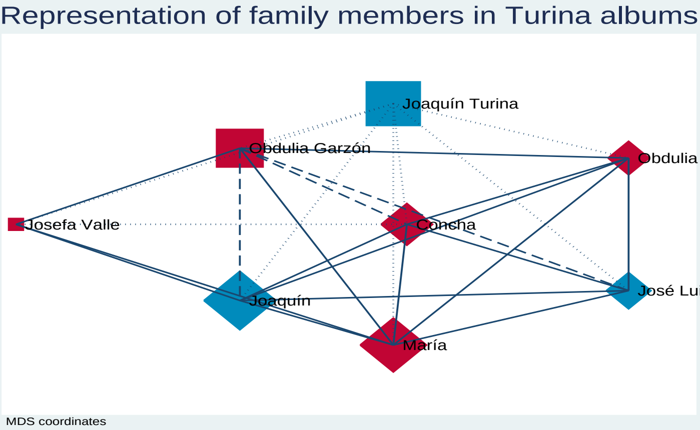
Spatial distribution of nodes

Five alternatives

- Network (Moreno 1934) and coincidence (Escobar 2009) analyses, based on Haberman residuals of **F** (circular coordinates).
- Other mappings of the adjacency matrix, based on Haberman residuals, can be used: multidimensional scaling (MDS) and cluster analysis.
- Or via correspondence analysis (Benzecri 1973), using matrix **X** as input and obtaining only column coordinates (incidents).
- Alternatively, we can obtain coordinates of events with principal component analysis (Pearson, 1901) using tetrachoric correlations (Everitt 1910).
- Or a biplot (Gabriel 1971) can be drawn with events as variables and suppressing scenarios (rows)

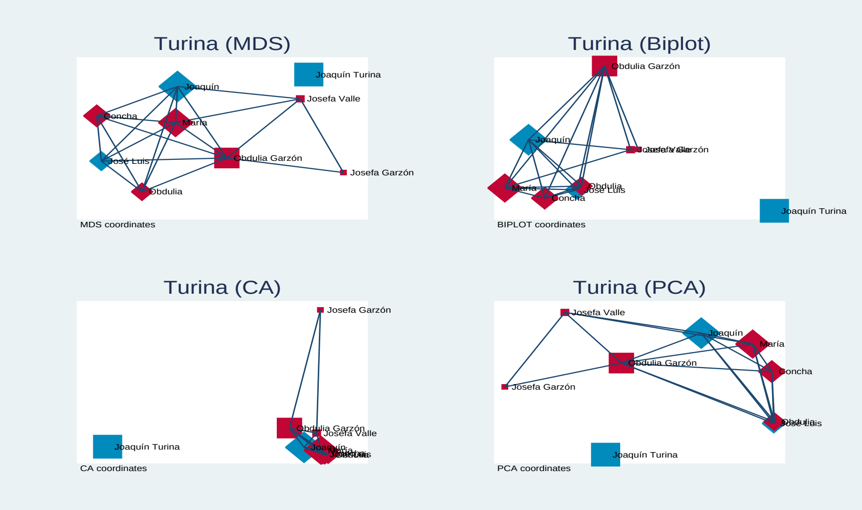
Multi-dimensional scaling graph of coincidences

Mere (· · ·), probable(- - -) and statistically probable (—) coincidences



Graph comparisons

MDS, Biplot, CA and PCA



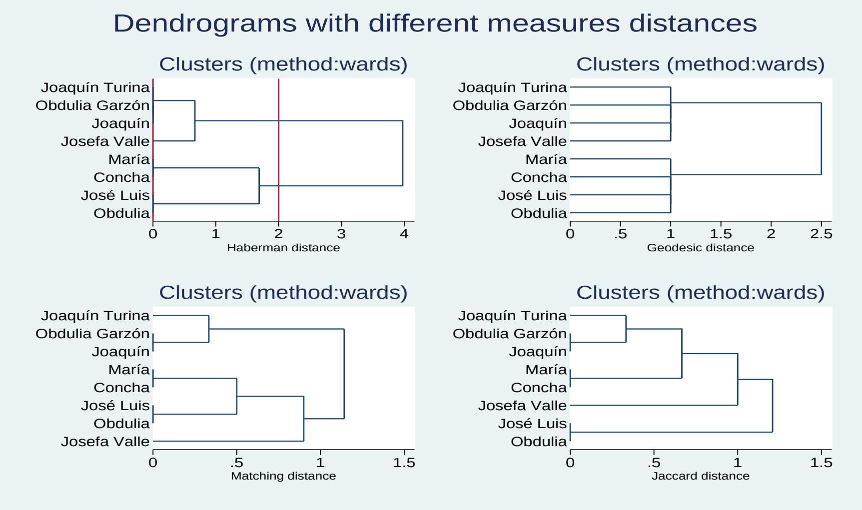
Clustering events

Definition

- Cluster analysis is “a set of methods for constructing a (hopefully) sensible and informative classification of an initially unclassified set of data, using the variable values observed on each individual ”(Everitt, 2003: 75).
- In agglomerative hierarchical clustering methods, there are various procedures to join cases: single, complete, average, median, Ward, ... using dendrograms.
- In the coincidence analysis, clustering could be useful to classify events according to their concurrences, using the Haberman residuals (r_{jk}) or another distance matrix (geodesic, matching, Jaccard, ...) as inputs to cluster.

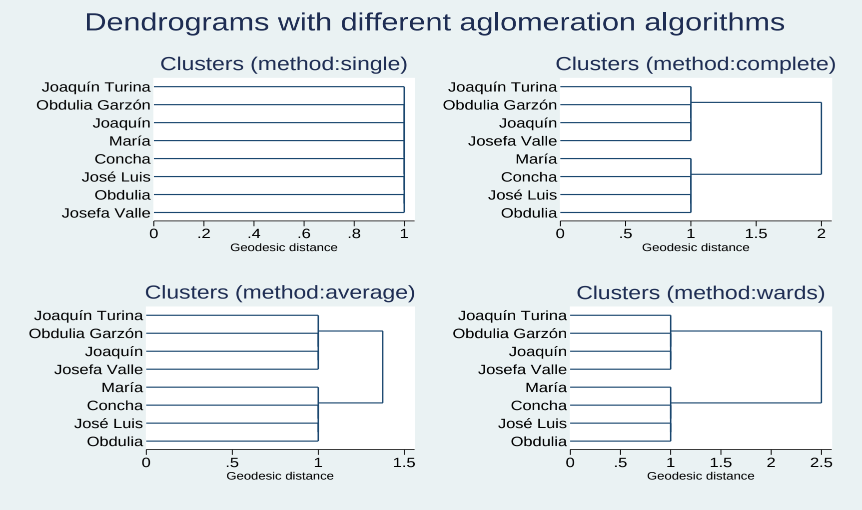
Different distances between events

Haberman-Geodesic-Matching-Jaccard



Different algorithms of agglomeration

Single-complete-average-Wards



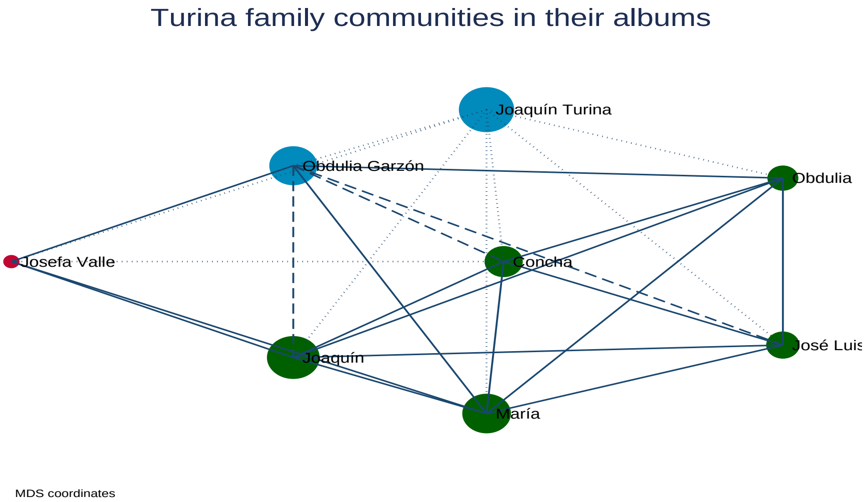
Structural equivalence and communities

Definition

- "Actors (events) j and k are structurally equivalent if, for all actors (events), $l = 1, 2, ..., g(k \neq j, k)$, and for all relations (associations) $r = 1, 2, ..., R$, actor (event) j has a tie to l if and only if k also has a tie to l, and j has a tie from l if and only if k also has a tie from l". (Wasserman and Faust 1994).
- Structurally equivalent events are those who have identical edges with the rest of events.
- A set of events or actors structurally equivalent is called a community.
- Events can be partitioned into subsets of structural equivalence using *hierarchical clustering* or CONCOR.

Representation of communities

Parents (blue), children (green) and mother-in-law (red)



coin

What is it?

- coin is an ado program in its development phase, which is capable of performing coincidence analysis
- Its input is a dataset with scenarios as rows and events as columns.
- Its outputs are:
  - Different matrices (frequencies, percentages, residuals (3), distances, adjacencies and edges)
  - Several bar graphs, network graphs (circle, mds, pca, ca, biplot) and dendrograms (single, average, waverage, complete, wards, median, centroid)
  - Measures of centrality (degree, closeness, betweenness, information) (eigenvector and power)
  - Options to export to excel and .csv files
- Its syntax is simple, but flexible. Many options (output, bonferroni, p value, minimum, special event, graph control and options, ...)

Social network program

Stata program

- Stata has commands for mds, pca, biplot, ca, cluster, ...
- Although there are no tools for SNA in Stata, some advanced users have begun to write some routines. I wish to highlight the following works from which I have obtained insights:
  - Corten (2010) wrote a routine to visualize social networks [netplot]
  - Mihura (2012) created routines (SGL) to calculate networks centrality measures, including two Stata commands [netsis and netsummarize]
  - Recently, White (2013) presented a suite of Stata programs for network meta-analysis which includes the network graphs of Anna Chaimani in the UK users group meeting. Grund and Hedstrom (2013, 2014) presented a collection of programs to plot and analyze social networks in the Nordic and Baltic Stata Users Group [nwcommands]. And Cerulli and Zinilii are presenting a procedure [datanet] in the 2014 Italian Stata Users Group meeting.

Command

coin

`coin` *varlist* [*if*] [*in*] [*weight*] [`using` *filename*] [, *options*]

Options can be classified into the following groups:

- **Outputs**:
  - Frequencies: frequencies g-relative-frequencies vertical % horizontal %, expected-frequencies odd-ratios,
  - Residuals: residuals standard-residuals normalized-residuals
  - Significance: phaberman podd ratios pfisher-exact-test
  - Others: tetrachoric-correlations, adjacencies-matrix distances list-key centrality measures, all-previous-statistics
  - Coordinates: x (with plot) xy(circle|mds|ca|pca|biplot).
- **Plots**
  - Bar: bar, cbar(*varname*)
  - Graph: plot(circle|mds|ca|pca|biplot)
  - Dendrograms: dendrogram(single|complete|average|wards)

Command

coin (continued)

`coin` *varlist* [*if*] [*in*] [*weight*] [, *options*]

Options can be classified into the following groups (continued):

- **Controls**: head(*varlist*), variable(*varname*), ascending, descending, minimum (#), support(#), pvalue(#), levels(# # #), bonferroni, lminimum(#), iterations(#).
- **Exports**
  - CSV: export(filename)
  - Graph: excel(filename)
  - nwcommands: nwsave(filename)

coin example (I)

Matrix of coincidences in the photograph albums of the Turina family

```
. coin Turina-Valle, frequencies

915 scenarios. 18 probable coincidences amongst 8 events. Density: 0.64
8 events(n>=5): Turina Garzon Joaquin Maria Concha JoseLuis Obdulia Valle
```

Frequencies	Tur~a	Gar~n	Joa~n	Maria	Con~a	Jos~s	Obd~a	Valle
Joaquín Turina	291							
Obdulia Garzón	42	216						
Joaquín	42	71	262					
María	25	62	124	222				
Concha	20	39	68	100	134			
José Luis	18	30	40	60	64	101		
Obdulia	13	27	33	54	60	58	86	
Josefa Valle	2	9	15	10	3	0	0	21

coin example (II)

Matrix of adjacencies in the photograph albums of the Turina family

```
. coin Turina-Valle, adjacencies

915 scenarios. 18 probable coincidences amongst 8 events. Density: 0.64
8 events(n>=5): Turina Garzon Joaquin Maria Concha JoseLuis Obdulia Valle
```

Adjacency matrix	Tur~a	Gar~n	Joa~n	Maria	Con~a	Jos~s	Obd~a	Valle
Joaquín Turina	0.0							
Obdulia Garzón	0.0	0.0						
Joaquín	0.0	1.0	0.0					
María	0.0	1.0	1.0	0.0				
Concha	0.0	1.0	1.0	1.0	0.0			
José Luis	0.0	1.0	1.0	1.0	1.0	0.0		
Obdulia	0.0	1.0	1.0	1.0	1.0	1.0	0.0	
Josefa Valle	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0

coin example (III)

Centrality measures in the photograph albums of the Turina family

```
. coin Turina-Valle, centrality
915 scenarios. 18 probable coincidences amongst 8 events. Density: 0.64
8 events(n>=5): Turina Garzon Joaquin Maria Concha JoseLuis Obdulia Valle
```

Centrality measures	Degree	Close	Between	Inform
Joaquín Turina	0.00	.	0.00	.
Obdulia Garzón	0.86	1.00	0.07	0.16
Joaquín	0.86	1.00	0.07	0.16
María	0.86	1.00	0.07	0.16
Concha	0.71	0.86	0.00	0.14
José Luis	0.71	0.86	0.00	0.14
Obdulia	0.71	0.86	0.00	0.14
Josefa Valle	0.43	0.67	0.00	0.11

Study of picture collections

Approach

- The aim is to analyze the set of people in three photograph collections.
- The first step is to quantify the number of pictures of every person.
- However, it is not only important how many times they appear, but also with whom.
- These ideas are based on the interactionist theory of the self outlined by G. H. Mead.
- The pictures will be considered as scenarios.
- People are going to be considered as incidences (variables). Do they appear or don't they?

Data

Sources

- The **Unamuno**'s archive contains around 1,117 pictures. A substantial part of them, 941, belonged to the familiar album.
  - This collection is from the "Casa-Museo Unamuno de la Universidad de Salamanca".
- The **Turina**'s archive consists of 1,438 photographs from the family album, plus over 1,800 other photos stored in folders.
  - The photos and Turina's archive come from the Spanish Library of Contemporary Music and Theatre (Juan March Foundation in Madrid).
- The **Masó**'s archive contains 237 family pictures. Its main character is Joan Masó (main photographer too).
  - These photos come from the "Fundació Rafael Masó's Archive"(Girona).
- The **Marcé**'s archive contains 959 pictures. La Argentina appears alone in 767 of them.
  - These photos are also from the Juan March Foundation in Madrid.

Miguel de Unamuno

Biography

- Miguel de Unamuno was born in Bilbao in September 1864.
- In 1880 he moved to Madrid to study Philosophy and Languages, and got married to Concha Lizárraga.
- He obtained a doctorate in 1883, and in 1891 he obtained the post of professor of Greek in the "Universidad de Salamanca".
- In the early 1900, he was appointed as the University Rector. Fourteen years later, he was removed by ministerial decree.
- In 1924 he was banished by General Primo de Rivera to Fuerteventura.
- He came back to the Universidad de Salamanca in 1930.
- During the II Republic (1931-1936), he was a member of the Spanish Parliament, and was again appointed as Rector.

Unamuno's Pictures

Unamuno (1864-1936)

Nuclear family

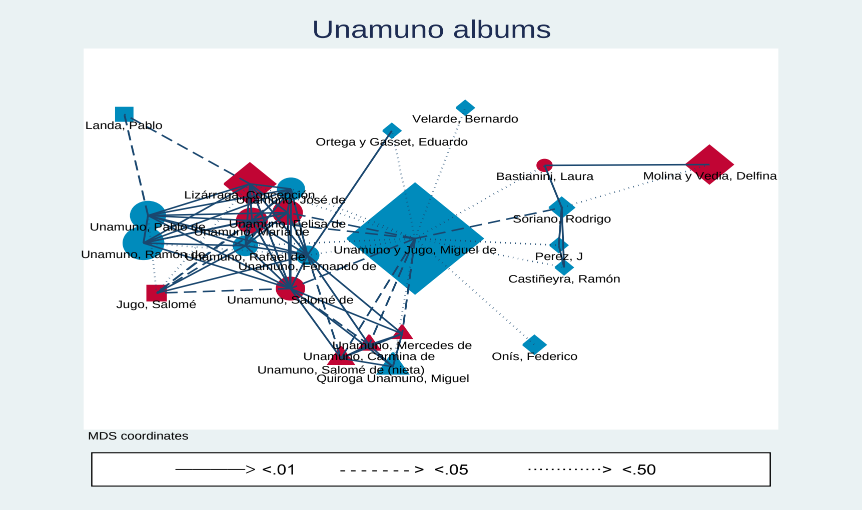
Unamuno-Lizárraga family

Public pictures

Unamuno

People in Unamuno's Albums

Family and colleagues (egonet)



Joaquín Turina

Biography

- Joaquín Turina Pérez was born in Seville in December 1882,
- He studied music in Madrid and Paris, where he met artists such as Isaac Albéniz and Manuel de Falla. He returned to Madrid at the beginning of World War I.
- He was responsible for the management of the theater Eslava in Madrid and from 1919 he served as the conductor of the "Teatro Real".
- In 1931 he became Professor of Composition at Conservatory of Madrid and in 1935 was appointed as a member of the "Real Academia de Bellas Artes de San Fernando".
- He died in 1949 leaving behind musicals like *Fantastic Dances* and *Fancy Clock*. He also published academic works like *A Treatise on Musical Composition* (1946).

Pictures of Turina

Turina (1882-1949)





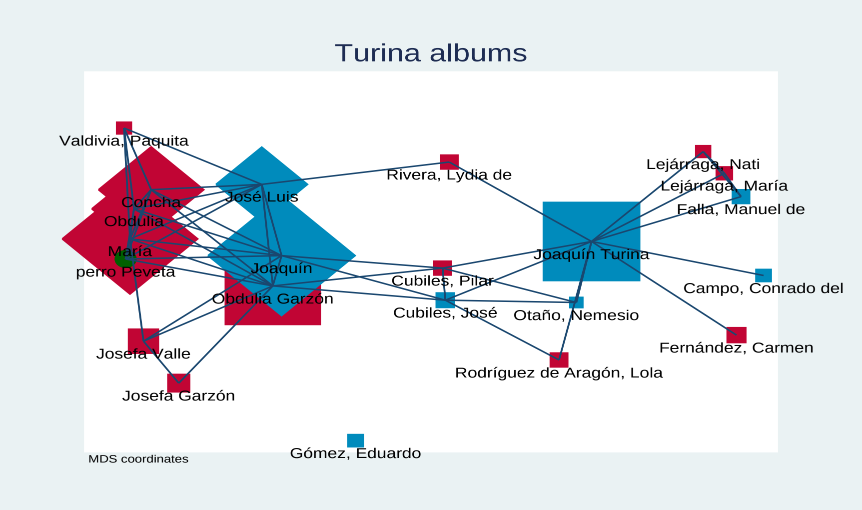
Family photos
Turina-Garzón family

Public pictures

Turina

People in Turina's Album

Family and colleagues



Rafael Masó

Biography

- Rafael Masó was born in Girona in August 1880. He was the second of eleven siblings.
- He was a architecture student in Barcelona where he moved to in 1900, was an admirer of Gaudí, and joined the Noucentisme, an alternative movement to Modernisme.
- Besides his architectural works, he was a Catalan nationalist,urban planner and promoter of art and literature
- His most outstanding works include the "Teixidor Flour Mill"(1910), the "Masó House"(1911), and the "Athenea cultural centre"(1912), all in Girona.
- He died in Girona in 1935, when he was 54.

Rafael Masó

(1880-1935)

Rafael Masó

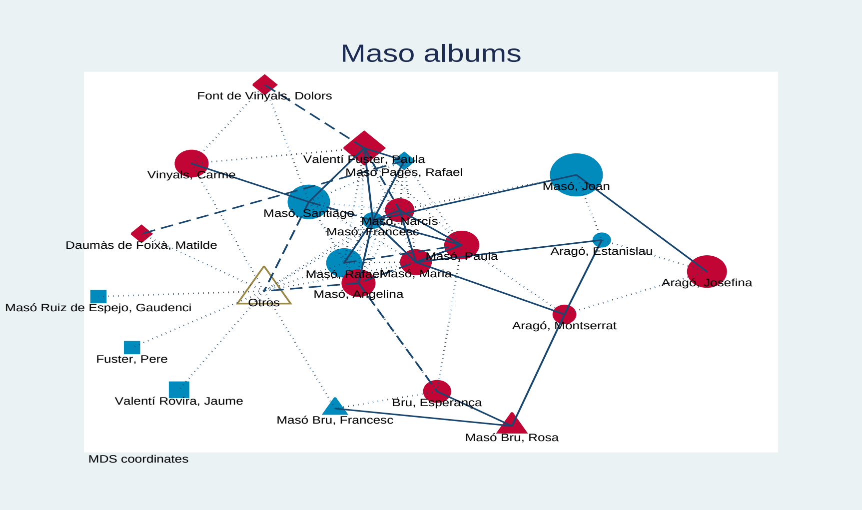
Masó-Valentí and Masó-Bru families

Public pictures

Masó

People in Masó's Collection

Egonet of Rafael Masó



Antonia Mercé (la Argentina)

Biography

- Antonia Mercé y Luque (La Argentina) was born in Buenos Aires in 1890. She was the daughter of two Spanish professional dancers.
- She was taught dance by her parents since she was 4, and performed at the Madrid Opera when she was 11.
- As her dancing was not very popular at the beginning, she had to move to Paris where she danced at the "Moulin Rouge "and the "Théâtre des Champs-Élysées "
- After returning to Spain, she danced pieces of the great Spanish composers of her time: Isaac Albéniz, Manuel de Falla, Francisco Granados, and Joaquin Turina.
- Her most outstanding performances include concert, such as "Sevilla"(Albéniz) and "La Danza del Fuego"(Falla), and ballets, such as "El Amor Brujo"(Falla).
- She died on July the 18th 1936 in Bayonne (France).

Antonia Mercé (la Argentina)
(1890-1936)

Antonia Mercé (la Argentina)

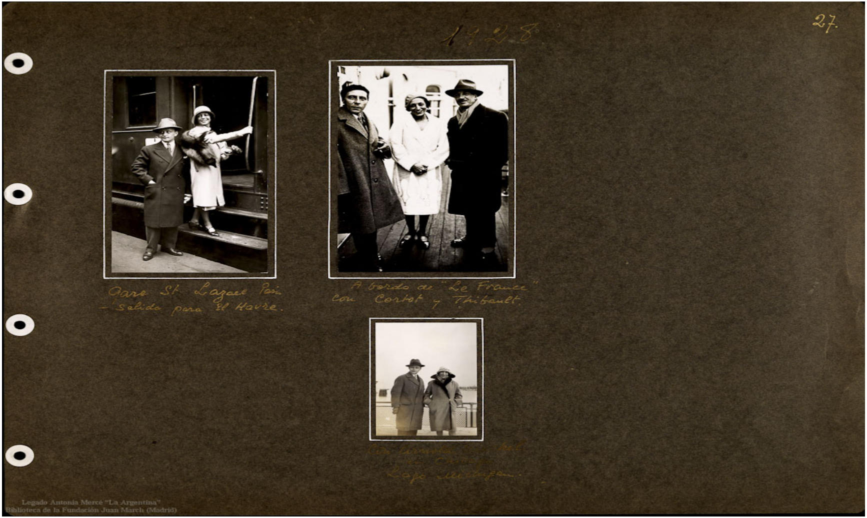
With differente dresses

Antonia Mercé (la Argentina)

Dancing "Aragonese jotas"

Antonia Mercé (la Argentina)

With Meckel and others

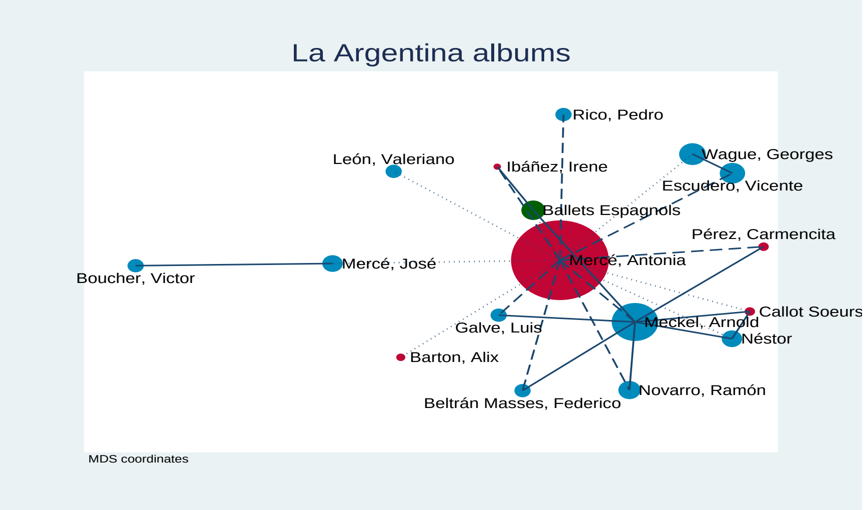


Antonia Mercé (la Argentina)

Rehearsing "El Amor Brujo"

La Argentina's book

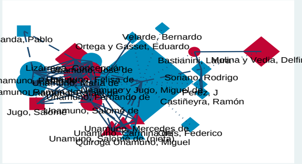
People in Antonia Mercé collection



Graphs comparison

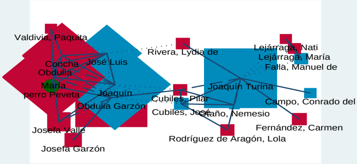
Unamuno, Turina, Masó, Mercé

Unamuno albums



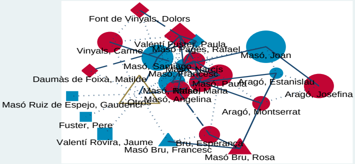
MDS coordinates

Turina albums



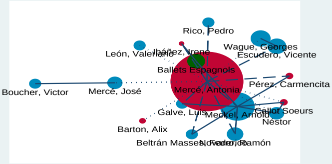
MDS coordinates

Masó albums



MDS coordinates

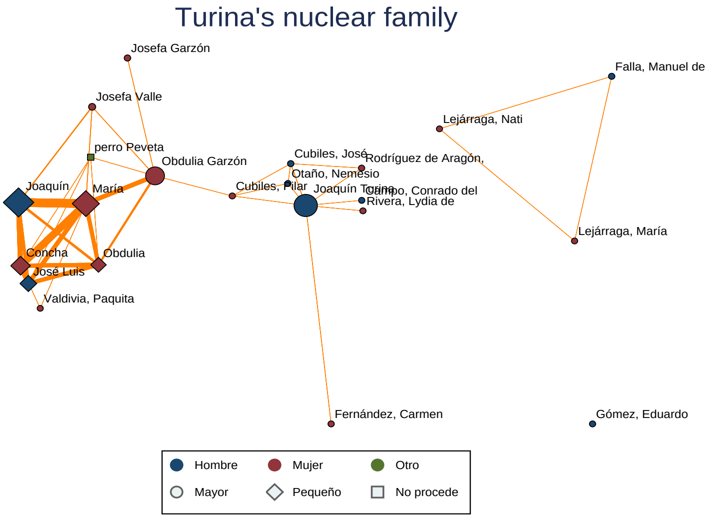
La Argentina albums



MDS coordinates

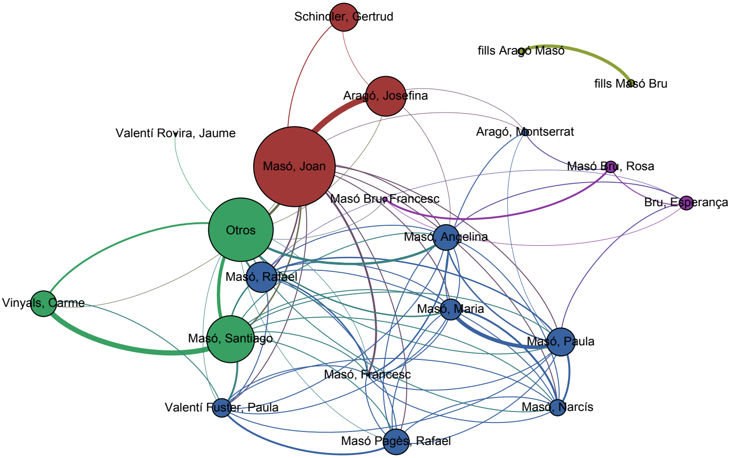
Maso’s family

Graph with nwcommands (after nw option of coin)



Maso's family

Graph with Gephi (after Stata export)



Remarks

About coincidence analysis

- I've proposed a manner of analyzing coincidences mixing different statistical tools.
- I think that the novelty of coincidence analysis is combining several techniques in order to represent reality graphically.
- This may also be useful in comparing different kinds of analysis with dichotomous variables.
- The above approach could be extensively used with the aid of the coin and other forthcoming programs.

Availability of coin

Frame Subtitle

- If you are users of a version superior to the 11.2 of Stata, you can have a free copy of coin by typing:
  - net install coin, from(http://sociocav.usal.es/stata/)
- It is still a beta version, but it works reasonably well and it is being improved. It could be updated as follows:
  - adoupdate, update
- Comments and suggestions will be welcome!!

Next steps

For coin

- Convert the command coin into a system (Gould 2010).
- Time based study of coincidences using dynamic networks.
- Use of log-lineal models to discover n-coincidences.
- Partial coincidences bar plots.
- Similar graphs representation of correlations among quantitative variables.

Last slide

Thanks

Gràcies per la seva atenció!

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