Three models to shape the relationships between computer scientists and domain specialists

A case study from archaeology in France, 1950s–2000s

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Hepic seminar, online

Organising the development of computer applications in science

Some general and long-term problems

Case: archaeology in France from the 1950s

Organising the development of computer applications in science

- An old problem: creating engineers schools at the beginning of the 19th century was an answer (to train skilled applied mathematicians);
- more recently, creating complex systems institutes,
- even more recently, building a (non)discipline, “digital humanities”.

Some general and long-term problems

Case: archaeology in France from the 1950s

Organising the development of computer applications in science

Some general and long-term problems

- **training**: should the domain specialists be trained in methods? to which extent?
- which **division of labour** (if any) between domain specialists and specialist in methods? to which degree?
- **disciplinary aims**: how to make methodological developments and applications interesting both for the domain specialists and for the computer scientists? (in terms of scientific problems addressed, publication opportunities, etc.)
- **funding**: who should fund the costly automatic devices?
- **domination**: how to ensure that neither the domain specialists nor the method specialists will be in (symbolic or material) subaltern positions with each other?

Case: archaeology in France from the 1950s

Organising the development of computer applications in science

Some general and long-term problems

Case: archaeology in France from the 1950s

- organised as a discipline recently, from the 1940s (parallel to computer science);
- between the humanities and natural sciences (geology, physics, botany, etc.);
- particular ontological properties of archaeological entities, which are purely spatial or material, always determined in some extent by humans action, *but* cannot be studied in relation with human discourses and action;
- early and intense use of mathematics (from the 19th c.) and automation (from the 1950s, with pioneers), with strong interest in data representation (language).

Aims of this research

Case, approach, and data

Aims of this research

- Presenting relatively unknown early experiences related to computer applications in the humanities, from the case of archaeology in France from the 1950s;
- Arguing that studying these not so old experiences can help to think the current policies of science (at least, by demonstrating what has been already done and forgotten) and balance the current discourses of radical novelty.

Case, approach, and data

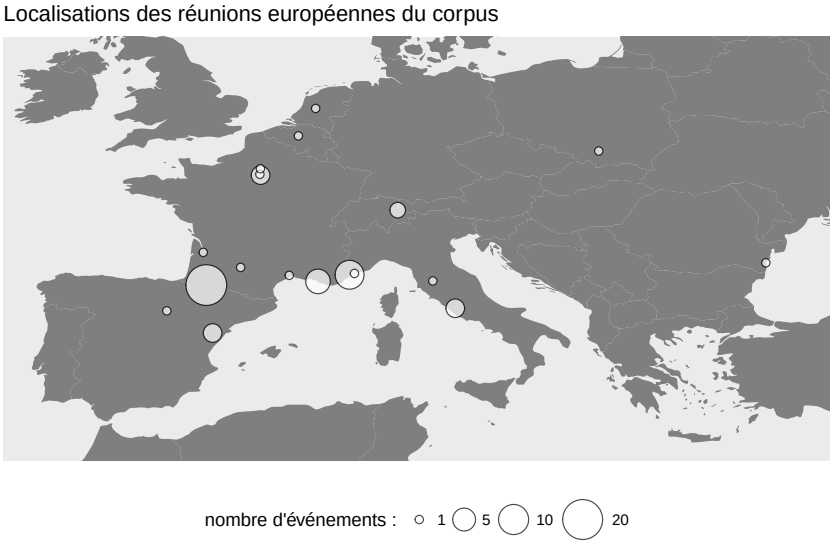
Aims of this research

Case, approach, and data

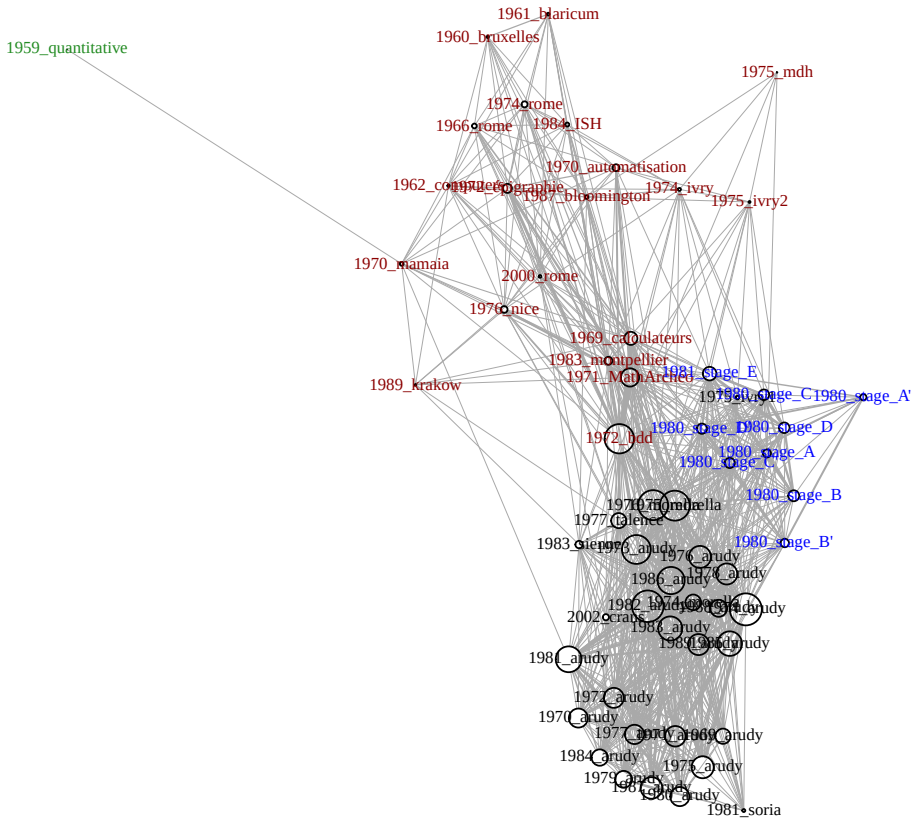
- approach: historical sociology (mixing narrative and formalised methods, including network analysis, sequence analysis);
- data: publications, archives (extraction of narrative and quantitative data), bibliometric data, interviews;
- chapter extracted from a PhD (2017)

Approximating the social space of computer applications in archaeology through an analysis of the co-presence of actors to conferences.

- 59 conferences, held between 1959 and 2002,
- 1057 different participants



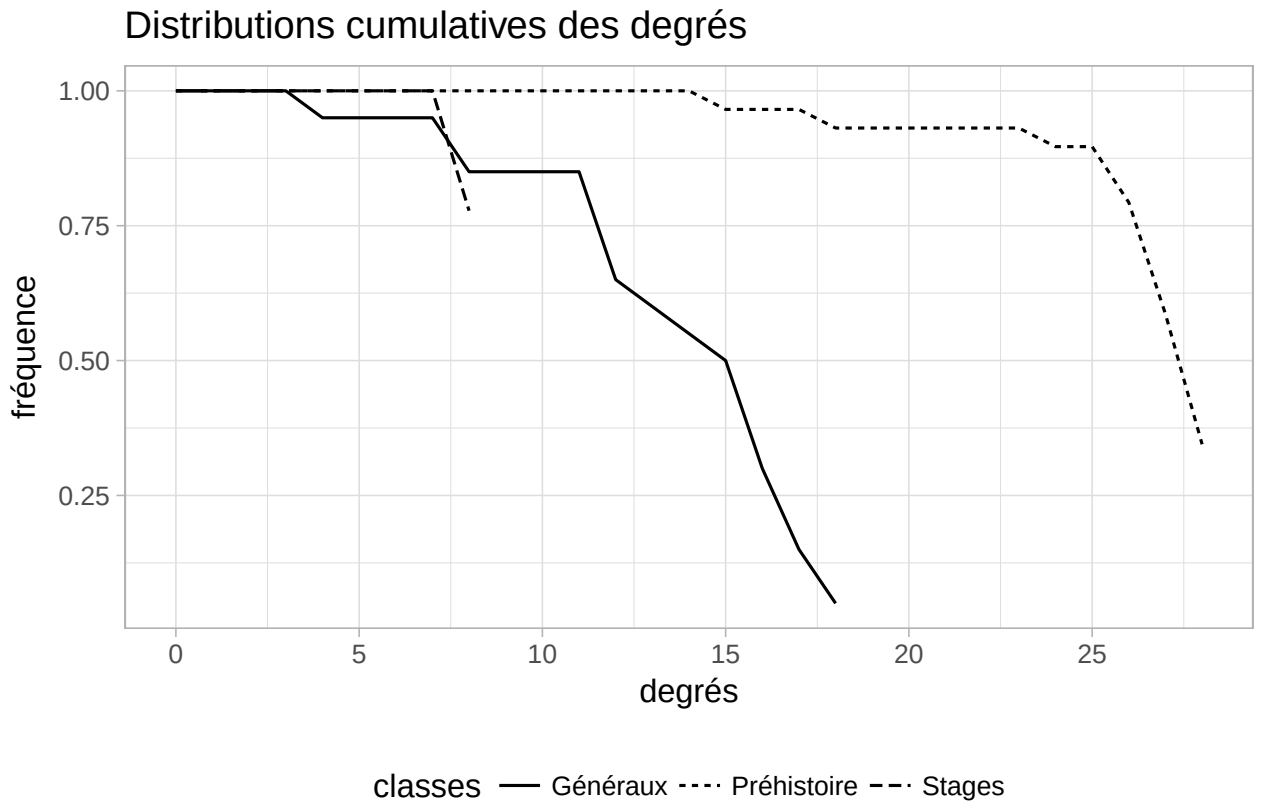
Relations entre événements



algorithme: walktrap, modularité : 0.32
taille des sommets : centralité de degré pondéré

Results

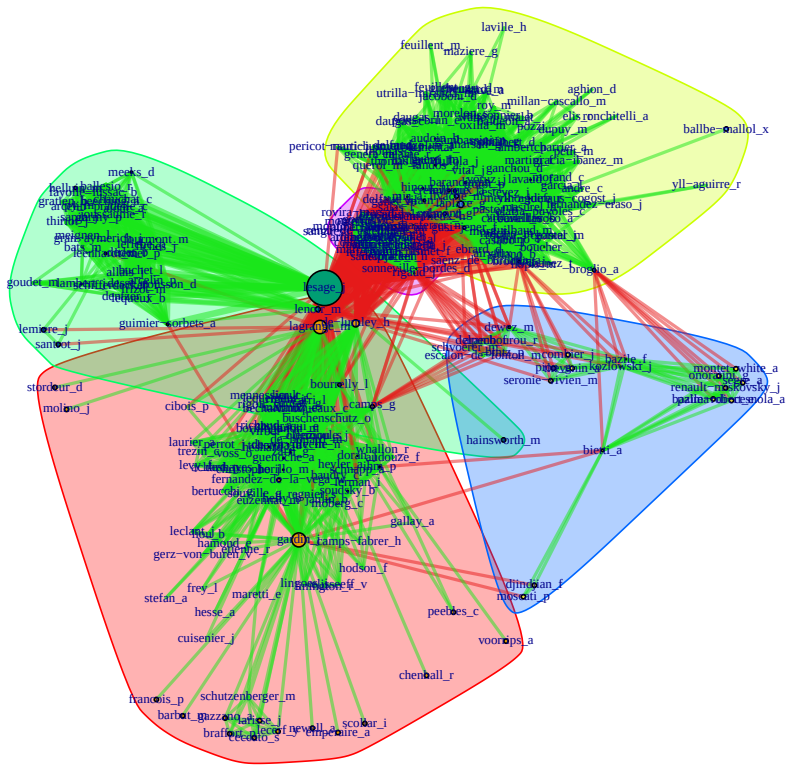
- 3 clusters are distinguished, but with a low partition quality (modularity: 0.32):
- the 3 clusters correspond to the events related to three major experiences about formal approaches in archaeology in France, namely:
  1. Jean-Claude Gardin's research projects and organisations;
  2. Georges Laplace's research group in prehistoric archaeology;
  3. activities organised within the *Centre de recherches archéologiques* (CRA).
- However, the low partition quality also reflects that these 3 experience had relationships.


Distributions cumulatives des degrés
1.00
0.75
0.50
0.25
fréquence
0
5
10
15
20
25
degrés
classes
Généraux
Préhistoire
Stages

In brief

- Threshold: two actors are linked if they participated at least to two conferences together (to ensure they share a common interest and did not meet by chance);
- Result: clustering in 5 clusters, with a fair partition quality.

Relations de coprésence des acteurs.
(lien >=2)



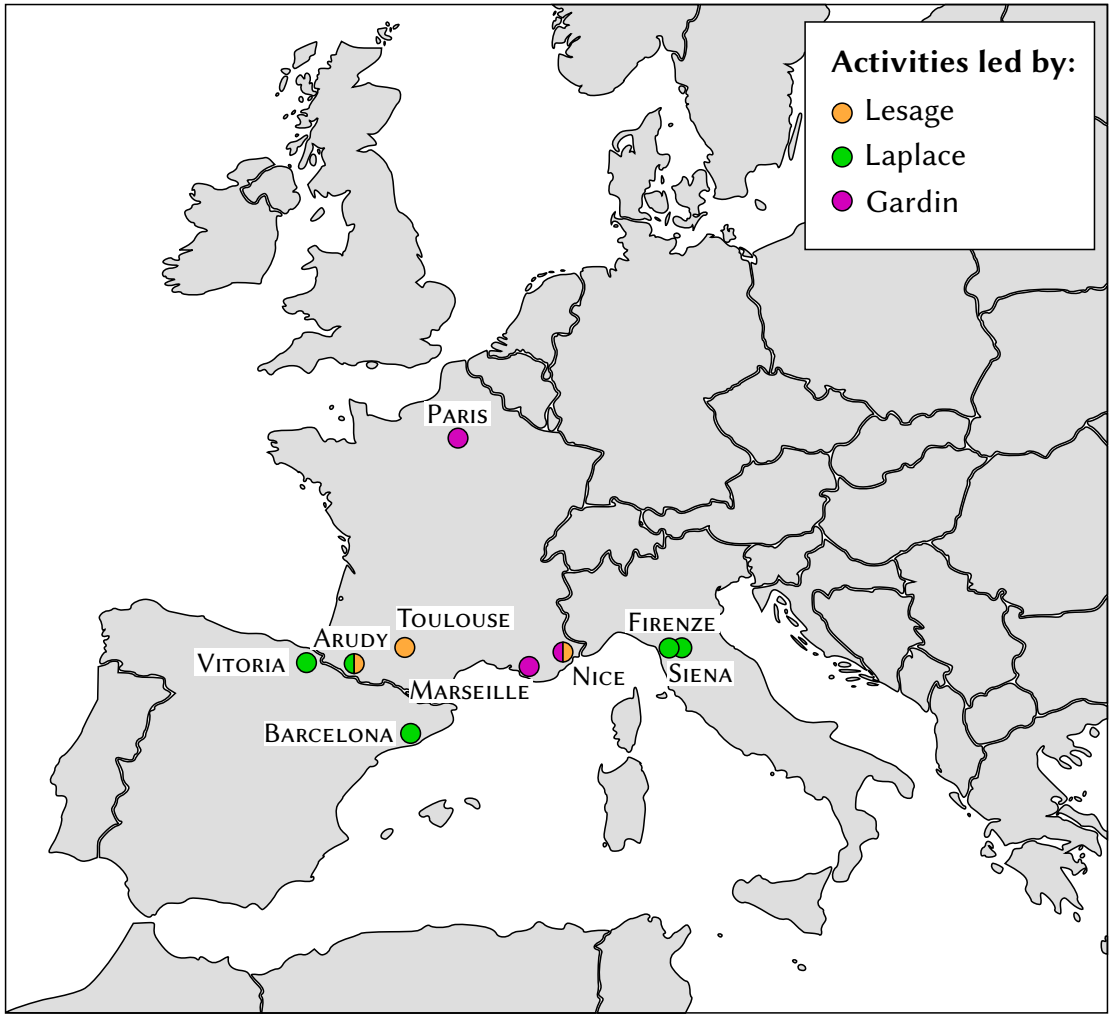
taille des sommets : intermédiarité / max(intermédiarité) * 10

couleurs des sommets : classes (algorithme: fast greedy, modularité : 0.52)

Results: 5 classes

1. archaeologists and mathematicians related to Gardin's activity, mostly French;
2. archaeologists related to Laplace's research group, French, Italian, and Spanish;
3. archaeologists related to the Cra, all French;
4. French and Italian archaeologists, most of them specialised in prehistory;
5. a general class of prehistoric archaeologists:
   - most of them being from Spain and related to Laplace's work ;
   - Henri Lefebvre, a French philosopher in contact with Laplace's group;
   - some French archaeologists, who had significant intellectual or administrative places.

Main locations of the researches discussed



Georges Laplace
(1918–2004)
here in Gatzarria cave
in 1952.

1938	school teacher;
1938–1947	mobilisation; commitment in the Resistance;
1948–1953	fieldwork in the Pyrenees;
1953–1955	1st fieldwork in north Africa (French colonies);
1955–1957	research stay in Italy;
1967	recruitment by the Cnrs;
1969–1989	animation of the "International group of typology", yearly seminars in Arudy;
1983	retirement;
1983–2004	late work on Pyrenean archaeology.

Key idea

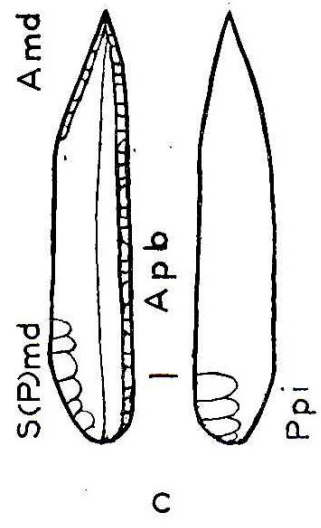
- Archaeological objects were usually represented using **natural language words** and **drawing**.
- Laplace's idea was to develop a third method: an artificial and specific "language".

The *typologie analytique* method includes and combines:

1. a **taxonomy**;
2. a set of **metric coefficients** and their **graphic representations**;
3. an articulated set of **statistical procedures**;
4. a coded **notation** for the description of the stones.

3 methods to represent lithic objects: natural language, drawing, code.

Pièce lamellaire, pointe à dos profond total, dextre, rectiligne, façonnée par une retouche abrupte profonde biface. Elle porte des retouches complémentaires : plate profonde inverse de la base, surimposée au dos ; abrupte marginale directe de la partie distale du bord réservé ; simple marginale directe, tendant vers plate, de la partie proximale du bord réservé.



$$\overline{\text{pD4}}\ \text{dext rect}\ \left[\text{Apb}\right]\ /\ =\ \text{Ppi base . Amd dist} - - \text{S(P)md prox}$$

Laplace 1968. "Recherches de typologie analytique 1968".

3 methods to represent lithic objects: natural language, drawing, code.

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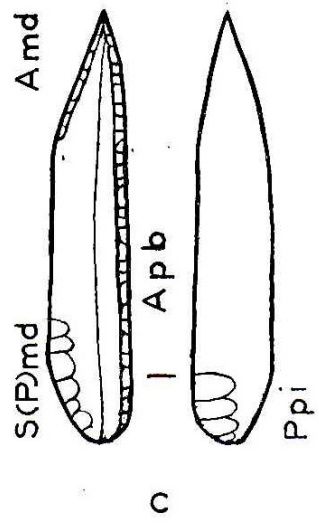


$$\overline{\text{pD4}}\ \text{dext rect}\ \left[\text{Apb}\right]\ /\ =\ \text{Ppi base}\ .\ \text{Amd dist}\ --\ \text{S(P)md prox}$$

Laplace 1968. "Recherches de typologie analytique 1968".

A formula in *typologie analytique* must have this syntax:

$$\textit{Primary type},\ \textit{position}\ \Big(\textit{tendency}\Big)\ \Big[\textit{morphotechnic features}\Big]\ /\ \textit{additional retouches}$$

Laplace 1974. "La typologie analytique et structurale : base rationnelle d'étude des industries lithiques et osseuses", p. 134.

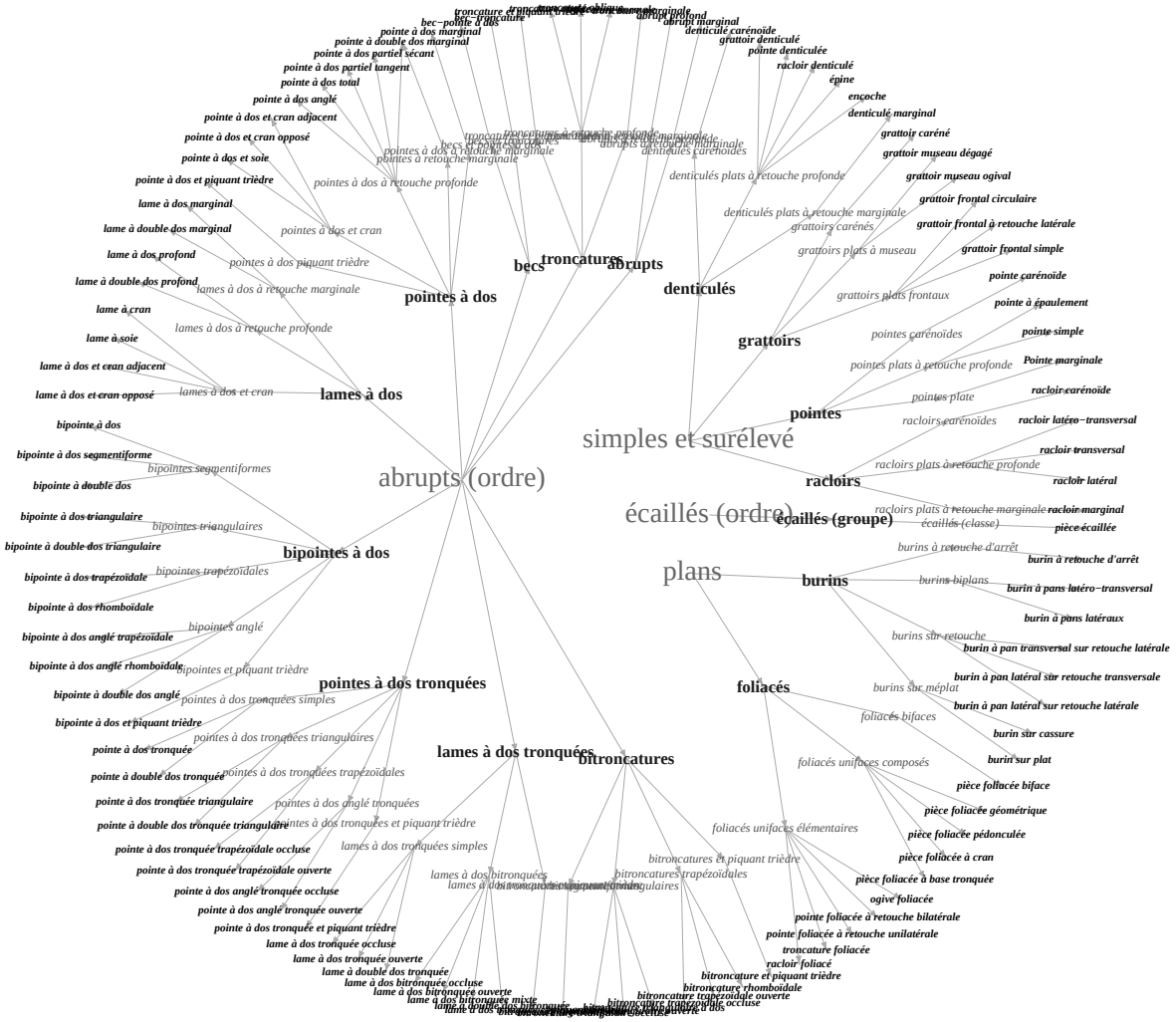
Graphic symbols

Sign	Utterance	Signified
$\bar{}$	overline	blade feature
—	simple dash	continue adjacency on the same edge
— —	double dash	discontinue adjacency on the same edge
=	duplicated dash	overlapping adjacency on the same edge
·	point	opposition
+ or ∩	plus or union	composition
( )	parentheses	tendency
[ ]	brackets	technical characteristics
/	stroke	complementarity

Summary of the "*signes analytiques*" from

Laplace 1968. "Recherches de typologie analytique 1968", p. 57 (my translation).

Georges Laplace's "analytical typology"



Taxonomy for the description of lithic objects (1972 version).

Laplace 1974. "La typologie analytique et structurale : base rationnelle d'étude des industries lithiques et osseuses".

What is being part of a scientific group?

Data

What is being part of a scientific group?

Considering 4 types of activities:

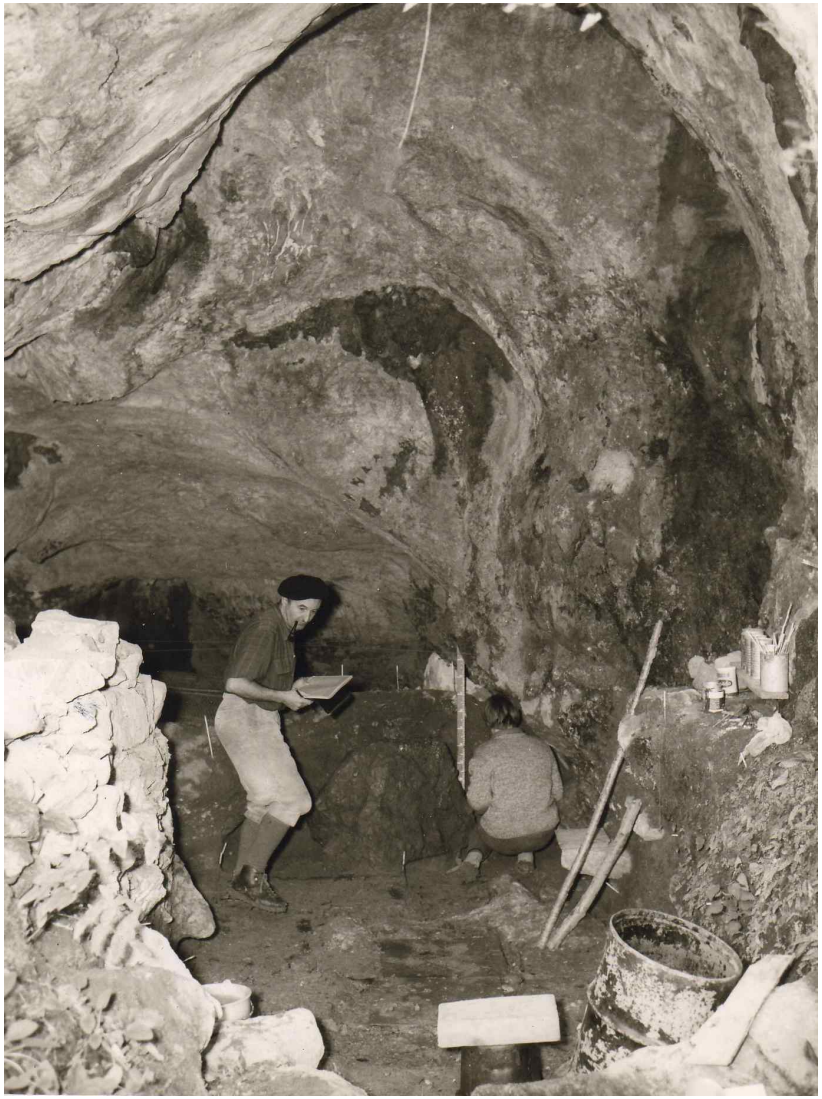
- **Data production**: being involved in excavations;
- **Conceptual production**: participating in typology seminars in Arudy;
- **Sharing information**: publication, in:
  - *Dialektikê. Cahiers de typologie analytique* (1972–1987),
  - *Archivio di tipologia analitica* (1973–1998).
- (Being recognized: being cited (in *Dialektikê*, *Archivio*). Not considered here.)

Data

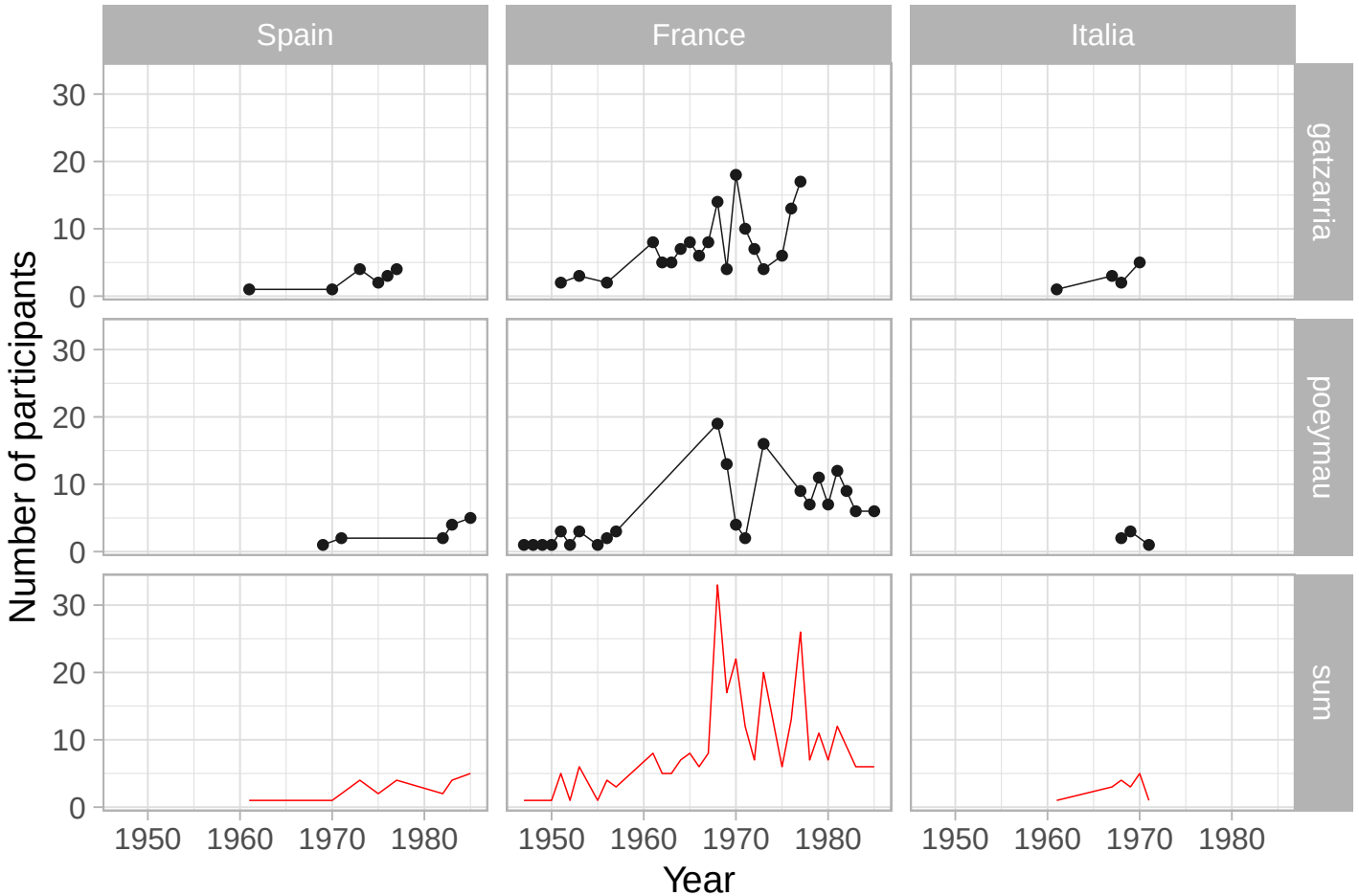
What is being part of a scientific group?

Data

- time range: 1947 to 1989;
- 318 actors;
- 17 seminars;
- 2 excavations.

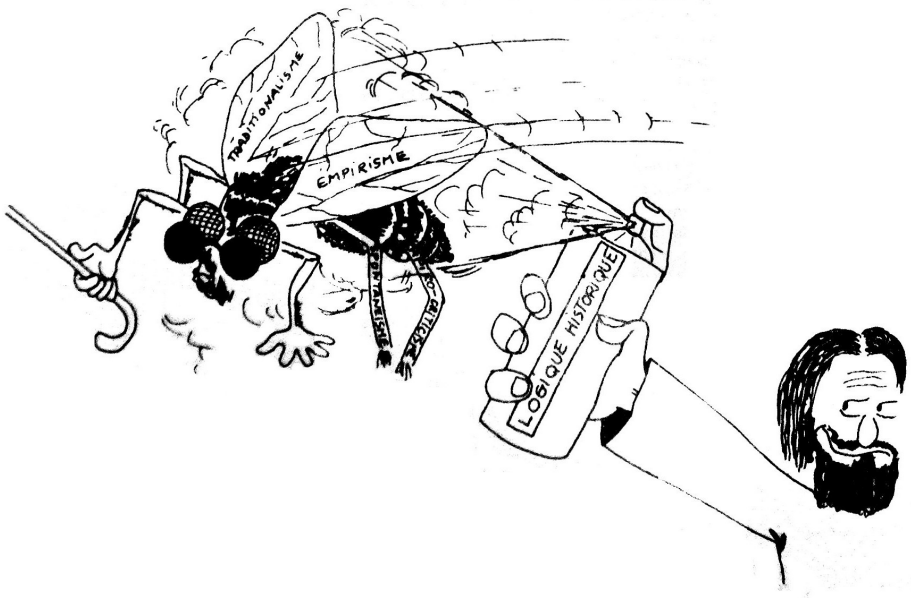


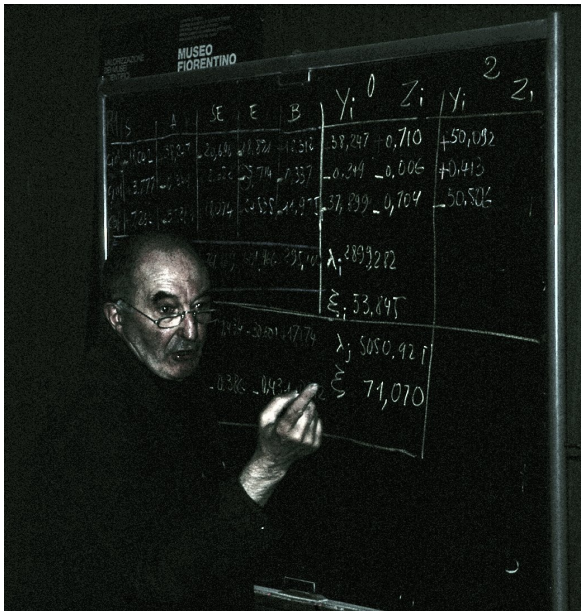
Excavation at the Gatzarria cave, 1968.



Nr of participants by nationality at the Gatzarria and Poeymaü excavations.

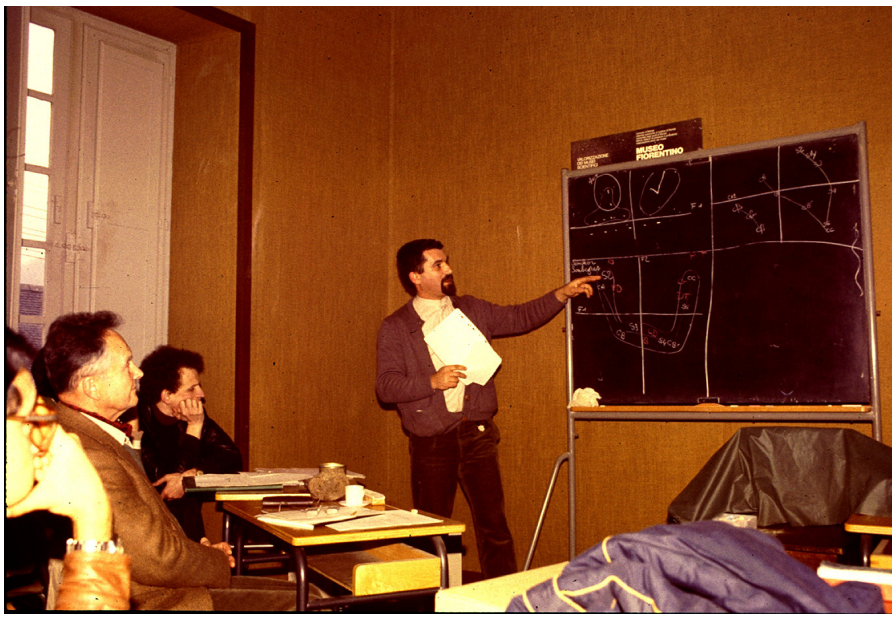
The international group of typology and the Arudy seminars (1969–1989)





Collective self-teaching in applied mathematics

The international group of typology and the Arudy seminars (1969–1989)



M. Livache presenting a correspondence analysis during the 1984 seminar.

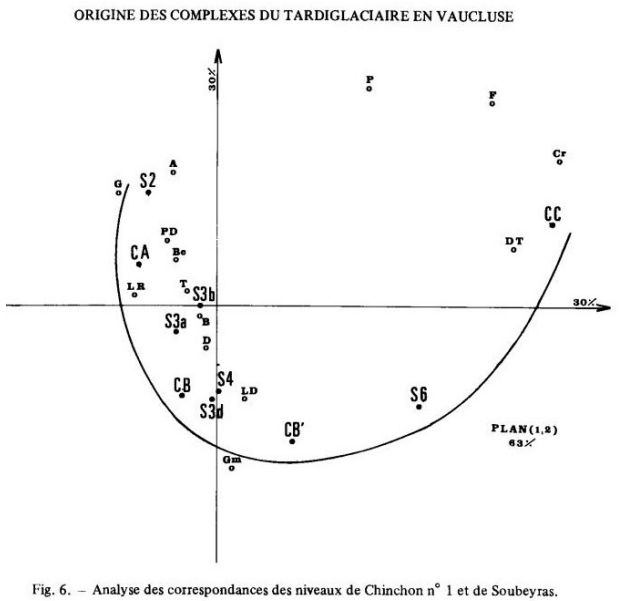
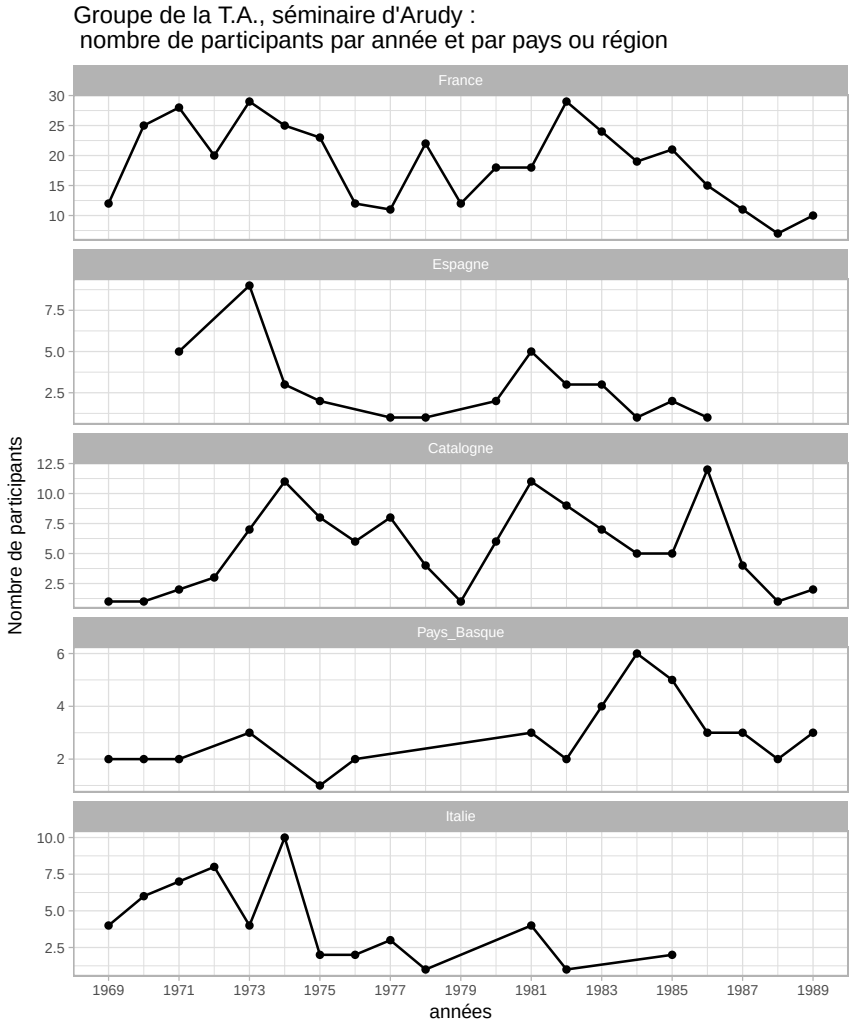


Fig. 6. – Analyse des correspondances des niveaux de Chinchon n° 1 et de Soubeyras.

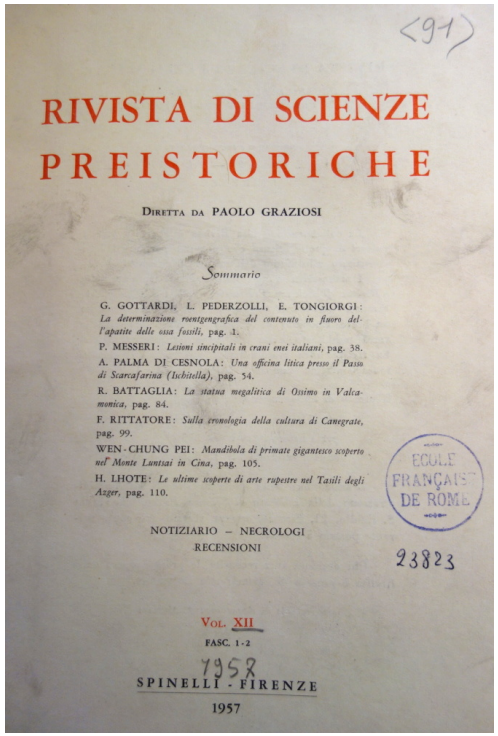
Brochier and Livache 1978. "Le niveau C de l'abri no 1 de Chinchon à Saumanes de Vaucluse : analyse des correspondances et ses conséquences quant à l'origine des complexes du Tardiglaciaire en Vaucluse", p. 367.



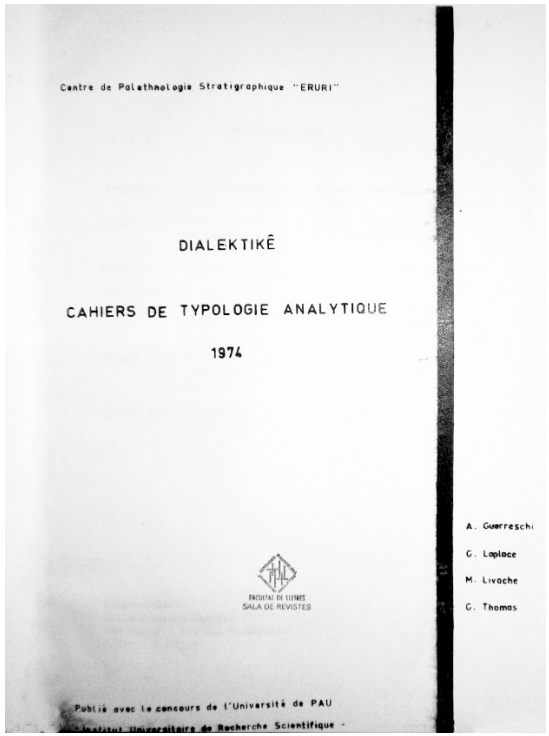
Number of participants by nationality.

- Italians: very involved until 1974 (then, some got academic positions).
- Catalan: participation stable through time.
- Basque: increase in the 1980s.

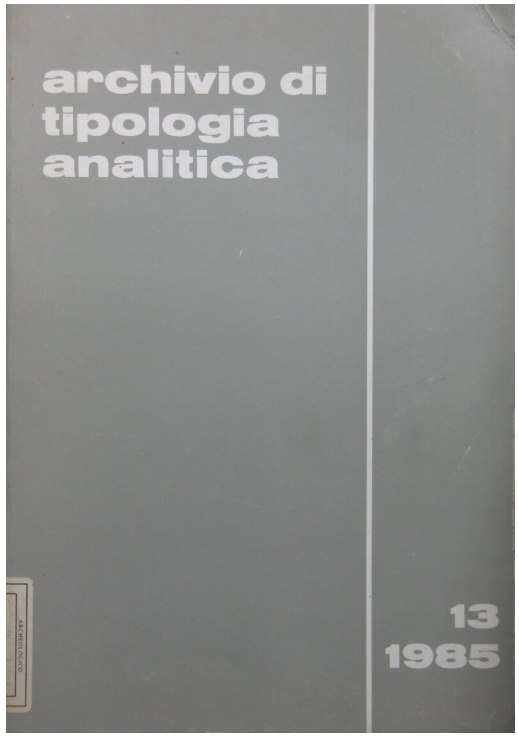
Main publishing vectors of the group



Rivista di scienze preistoriche
1946–

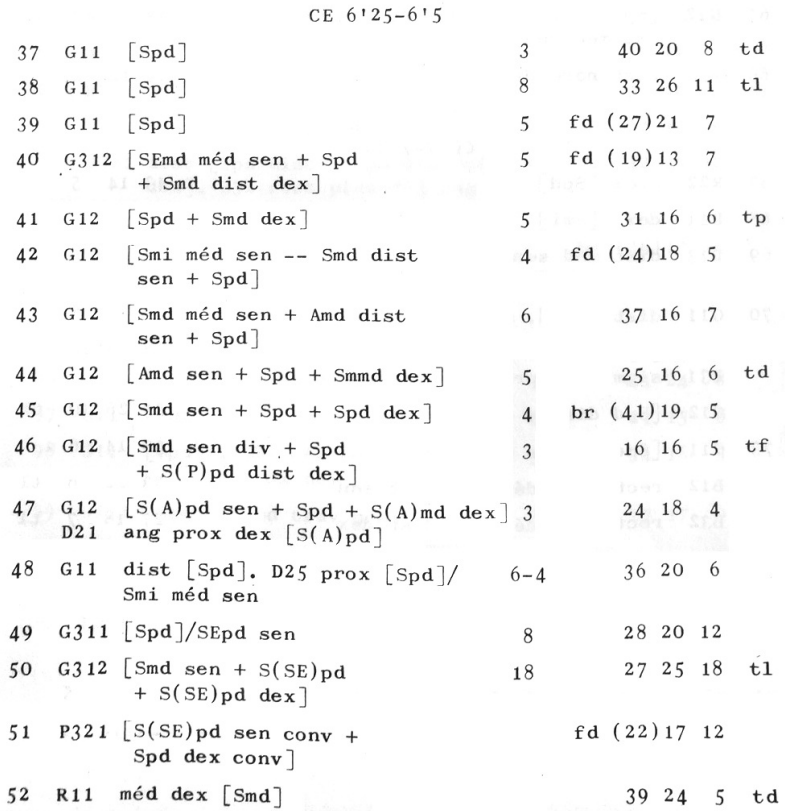


Dialektikê
13 volumes
1972–1987 + 2006



Archivio di tipologia analitica
21 volumes
1973–1998

The *Archivio di tipologia analitica* journal.

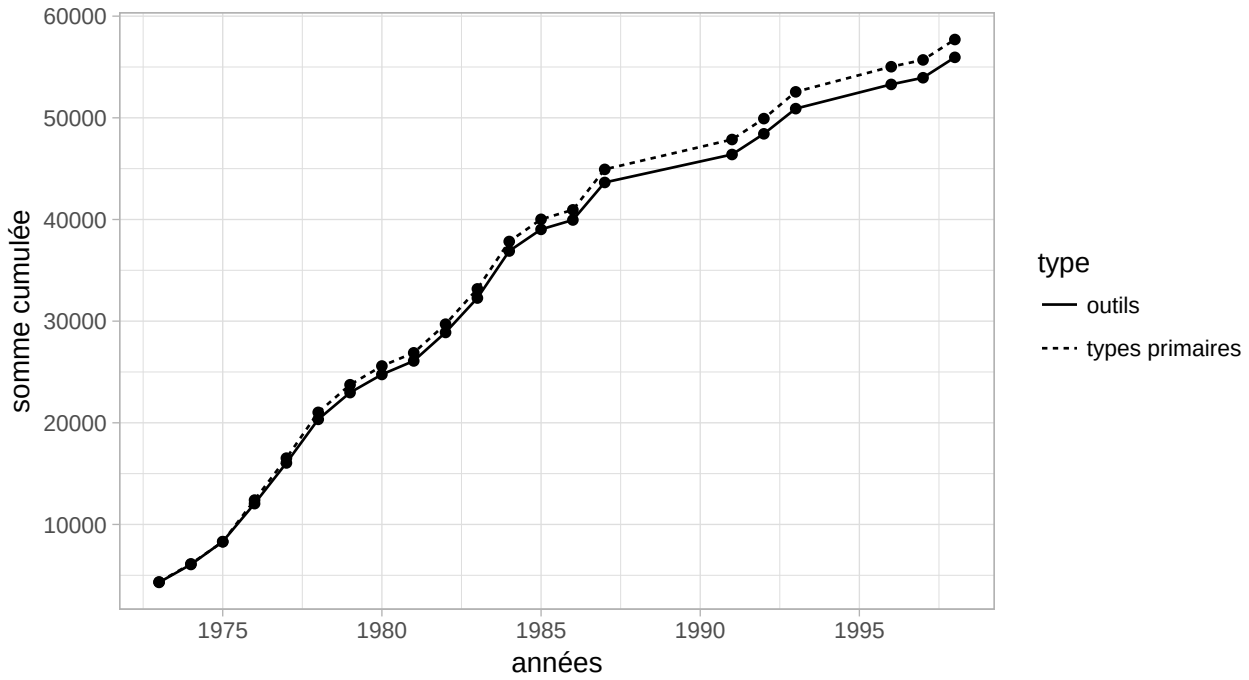


CE 6'25-6'5

37	G11	[Spd]	3	40 20 8		td
38	G11	[Spd]	8	33 26 11		tl
39	G11	[Spd]	5	fd (27)21 7		
40	G312	[SEmd méd sen + Spd + Smd dist dex]	5	fd (19)13 7		
41	G12	[Spd + Smd dex]	5	31 16 6		tp
42	G12	[Smi méd sen -- Smd dist sen + Spd]	4	fd (24)18 5		
43	G12	[Smd méd sen + Amd dist sen + Spd]	6	37 16 7		
44	G12	[Amd sen + Spd + Smmd dex]	5	25 16 6		td
45	G12	[Smd sen + Spd + Spd dex]	4	br (41)19 5		
46	G12	[Smd sen div + Spd + S(P)pd dist dex]	3	16 16 5		tf
47	G12 D21	[S(A)pd sen + Spd + S(A)md dex] ang prox dex [S(A)pd]	3	24 18 4		
48	G11	dist [Spd]. D25 prox [Spd]/ Smi méd sen	6-4	36 20 6		
49	G311	[Spd]/SEpd sen	8	28 20 12		
50	G312	[Smd sen + S(SE)pd + S(SE)pd dex]	18	27 25 18		tl
51	P321	[S(SE)pd sen conv + Spd dex conv]		fd (22)17 12		
52	R11	méd dex [Smd]		39 24 5		td

Fullola Pericot 1976. "Cova del Parpalló (Gandía, Valencia, Spagna)".

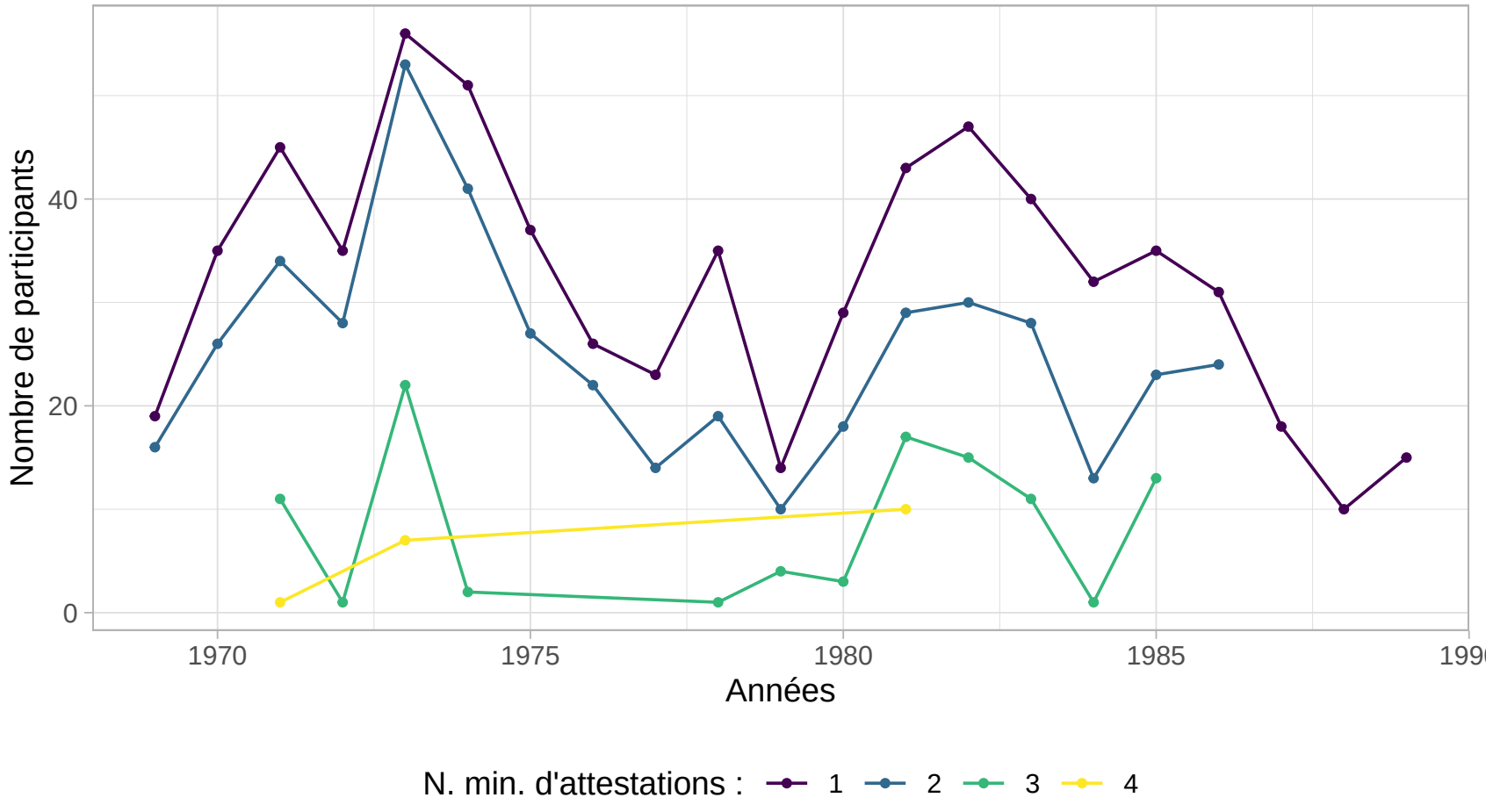
The *Archivio di tipologia analitica* journal.



Cumulative number of tools (solid line) and of "primary types" published in the journal between 1973 and 1998.

Simple questions

1. Who participated in the Typology seminars and when?
2. Who did what?



Number of participants by year (as a function of the number of sources cross-validating each participation).

The division of labour

Data and states

The division of labour

Four actions:

1. generating data
2. producing concepts and methods
3. applying methods
4. transmission of knowledge

Data and states

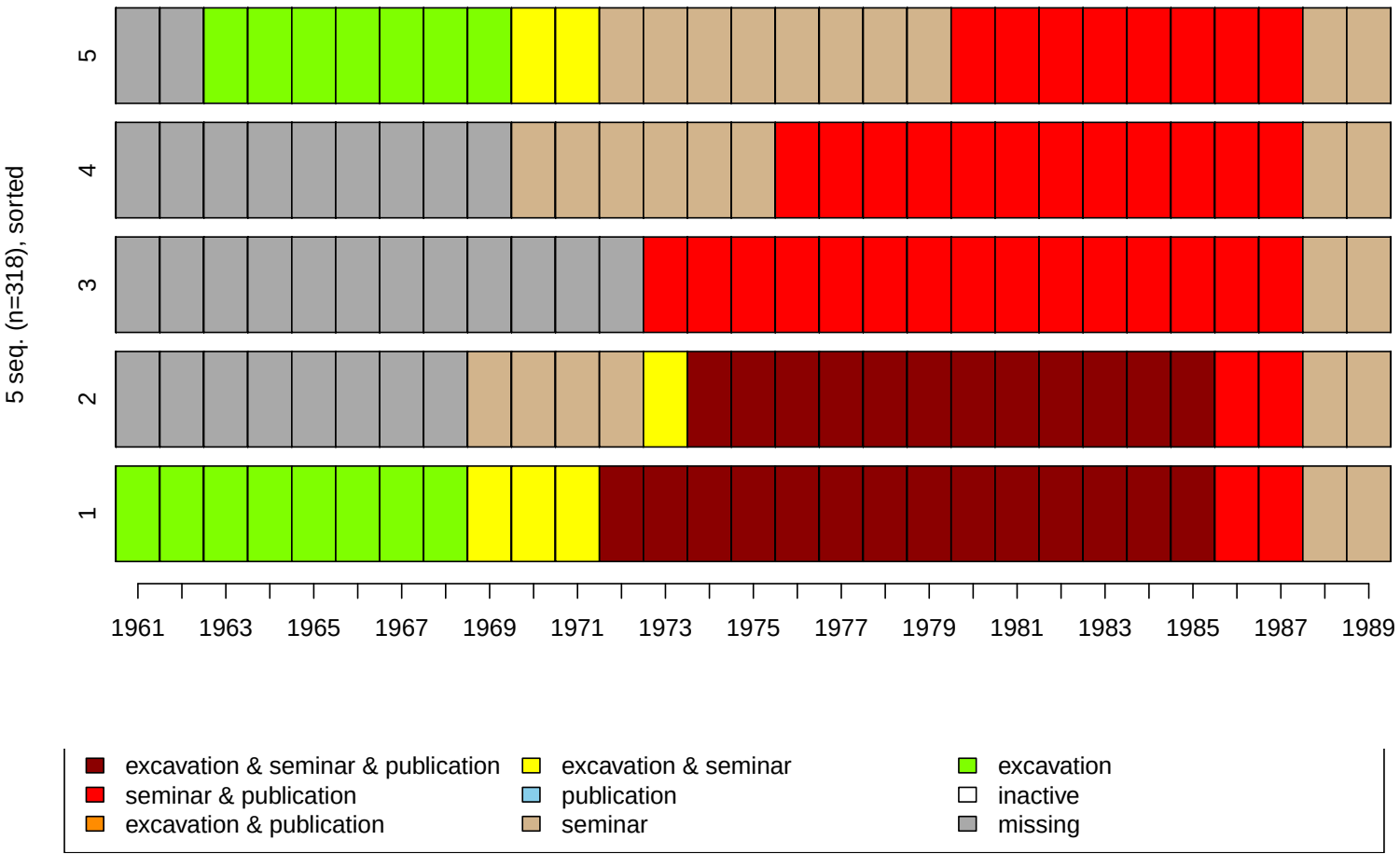
The division of labour

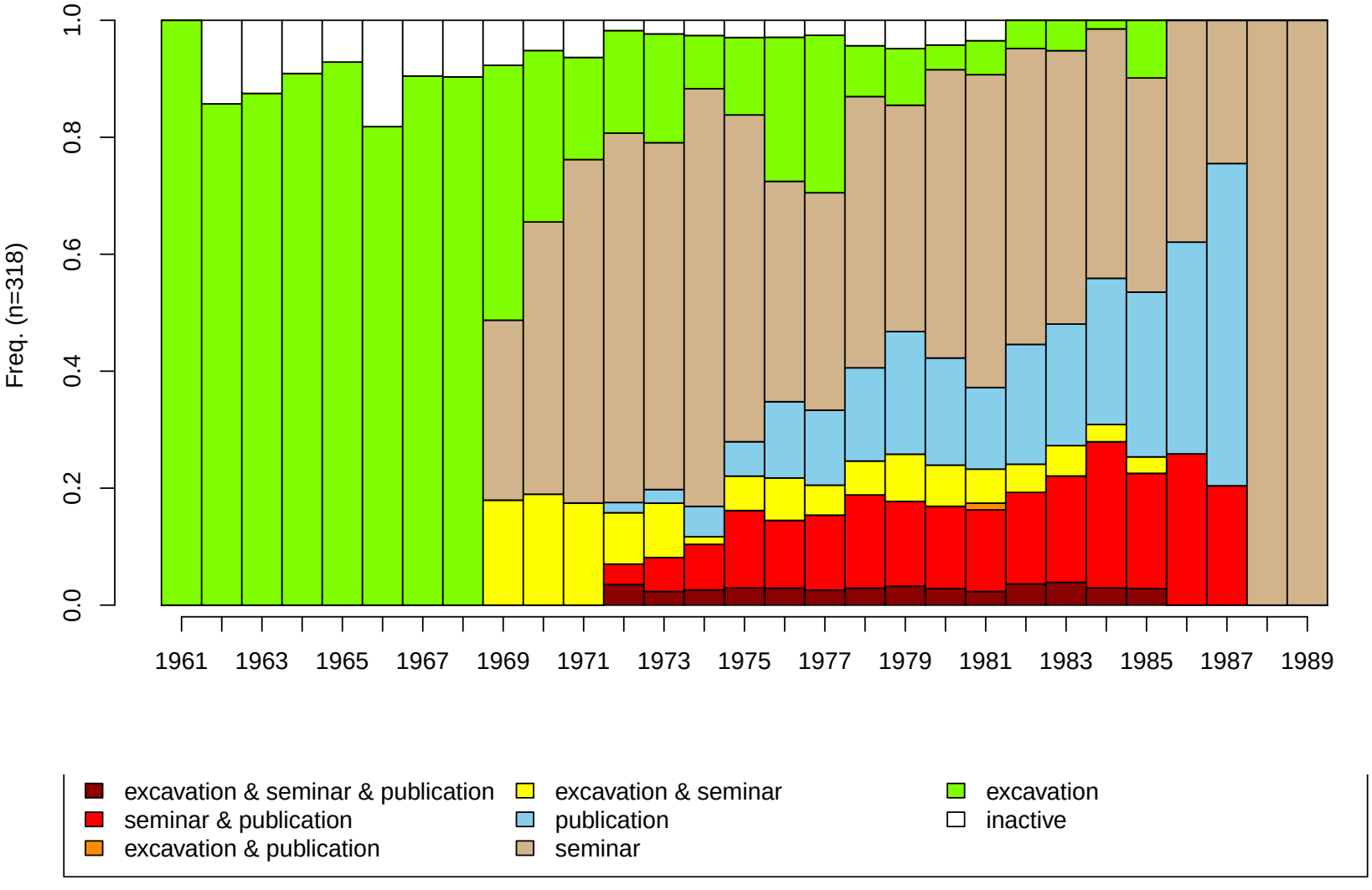
Data and states

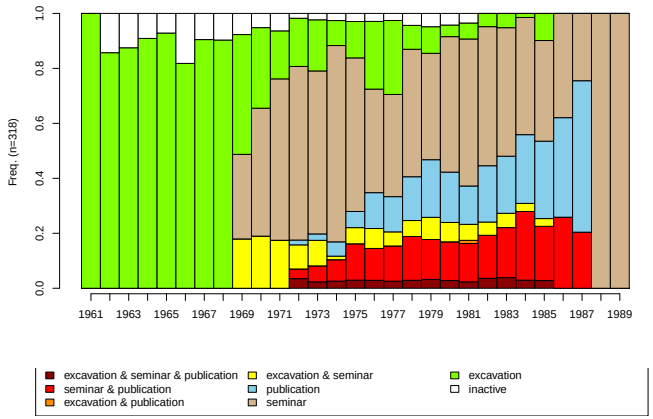
Individual sequences for 318 actors and 8 states:

1. inactive,
2. excavations (at the Gatzarria & Poeymaü sites),
3. participation in the Arudy seminars,
4. publication in *Dialektikê* or *Archivio*,
5. excavation & seminar,
6. excavation & publication,
7. seminar & publication,
8. excavation & seminar & publication.

Example of four individuals sequences:




Freq. (n=318)
0.0
0.2
0.4
0.6
0.8
1.0
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
excavation & seminar & publication
seminar & publication
excavation & publication
excavation & seminar
publication
seminar
excavation
inactive



- a division of labour is detected: excavation / publication / participation in the seminar.
- the rate of **excavation & seminar & publication** (=core of the research group) is stable;
- the rate of people participating the **seminar** & **publishing** increases over the study period;
- the rate of people participating only in the **excavation** decreases over the study period;

Jean-Claude Gardin (1925–2013), Linguist, archaeologist, documentation expert.

- 1925: birth in Paris;
- 1940–1945: military activity (Free French navy);
- 1948–1950: *bachelors* in economics (LSE), linguistics and ethnology (Paris), Persian (Paris);
- 1952–...: archaeological research in the Middle East;
- 1955–...: research in information retrieval, semiology, linguistics, automatic documentation;
- 1955–1962: collaborations with C. Lévi-Strauss;
- 1957–...: creation and/or direction de many scientific organisations related to archaeology and/or scientific documentation;
- 1962: senior researcher at the Ephe, Paris.
- 1964: move to Marseilles, to led the *Centre d'automatique documentaire pour l'archéologie* (Cada).

Gardin participated in the early key conferences

- *International Conference on Scientific Information*
- organised by the National Academy of Sciences, National Research Council
- 16–21 November 1958, Washington
- Gardin 1959. "On the Coding of Geometrical Shapes and Other Representations, with Reference to Archaeological Documents".

Gardin participated in the early key conferences

- *International Conference on Information Processing*
- organised by the Unesco
- 15–20 June 1959, Paris
- *Symposium on the Use of Automatic Computation Techniques in the Social Sciences*: Gardin and Braffort 1960. "Mise en évidence et exploitation mathématique des structures dans les phénomènes humains. Étude topologique des formes de vases".

Gardin participated in the early key conferences

- *Preparatory training in automatic documentation techniques*
- organised by André Leroy (ex-Cea) from the Cetis
- 15–22 February 1960, Bruxelles
- Leroy 1960. *Enseignement préparatoire aux techniques de la documentation automatique.*

Preparatory training... (1960) program (1)

- Introduction:
  - A. Leroy, Présentation des cours
  - E. Pietsch, Les problèmes de la documentation
  - E. de Grolier, Historique des Systèmes documentaires
  - P. Braffort, Historique des machines à calculer
- Mathematics day:
  - P. Braffort, Introduction à la journée de mathématiques
  - M. Schützenberger, Théorie de l'information
  - A. Gazzano, Éléments de recherche opérationnelle
  - J. Larisse, Travaux pratiques de linguistique statistique
- Linguistics day:
  - A. Leroy, introduction à la journée de linguistique
  - S. Ceccato, I problemi filosofici del linguaggio
  - P. Braffort, Éléments de linguistique mathématique
  - V. Belevitch, On the statistical laws of linguistic distributions
  - Y. Lecerf, Travaux pratiques linguistique

Preparatory training... (1960) program (2)

- Documentation systems day:
  - A. Leroy, Élaboration d'un système documentaire
  - J.C. Gardin, Analyse et sélection documentaire dans les sciences humaines
  - Discussion sur les systèmes documentaires
- Analyse day:
  - M. Detant, Y. Lecerf, A. Leroy, Travaux pratiques sur l'établissement des diagrammes
  - Y. Lecerf, Analyse automatique (Programme d'une expérience par E. Morlet)
- Automatisation day:
  - Th. W. te Nuyl, The "L'Unité" documentation system
  - J. Poyen, Quelques problèmes posés par le traitement de l'information non numérique
  - J. Iung, Points communs entre les problèmes posés par la traduction automatique et la documentation automatique
  - A. Leroy, la documentation complètement automatique
  - P. Braffort, Conclusion générale

The "Leibniz" seminars (Cetis/Ibm)

- *Non Numerical data-processing Symposium*
- 24–27 April 1961, Blaricum (Netherlands), *IBM World Trade European Education Center*
- participants: Luitzen Egbertus Jan Brouwer, David Hirschberg, Silvio Ceccato, Paul Braffort, Claude Berge, Yves Lecerf, Jean-Claude Gardin...

- *On the Relationship between Non-numerical Programming and the Theory of Formal System*
- October 1961, Blaricum, *IBM World Trade European Education Center*
- Braffort and Hirschberg 1963. *Computer Programming and Formal Systems.*

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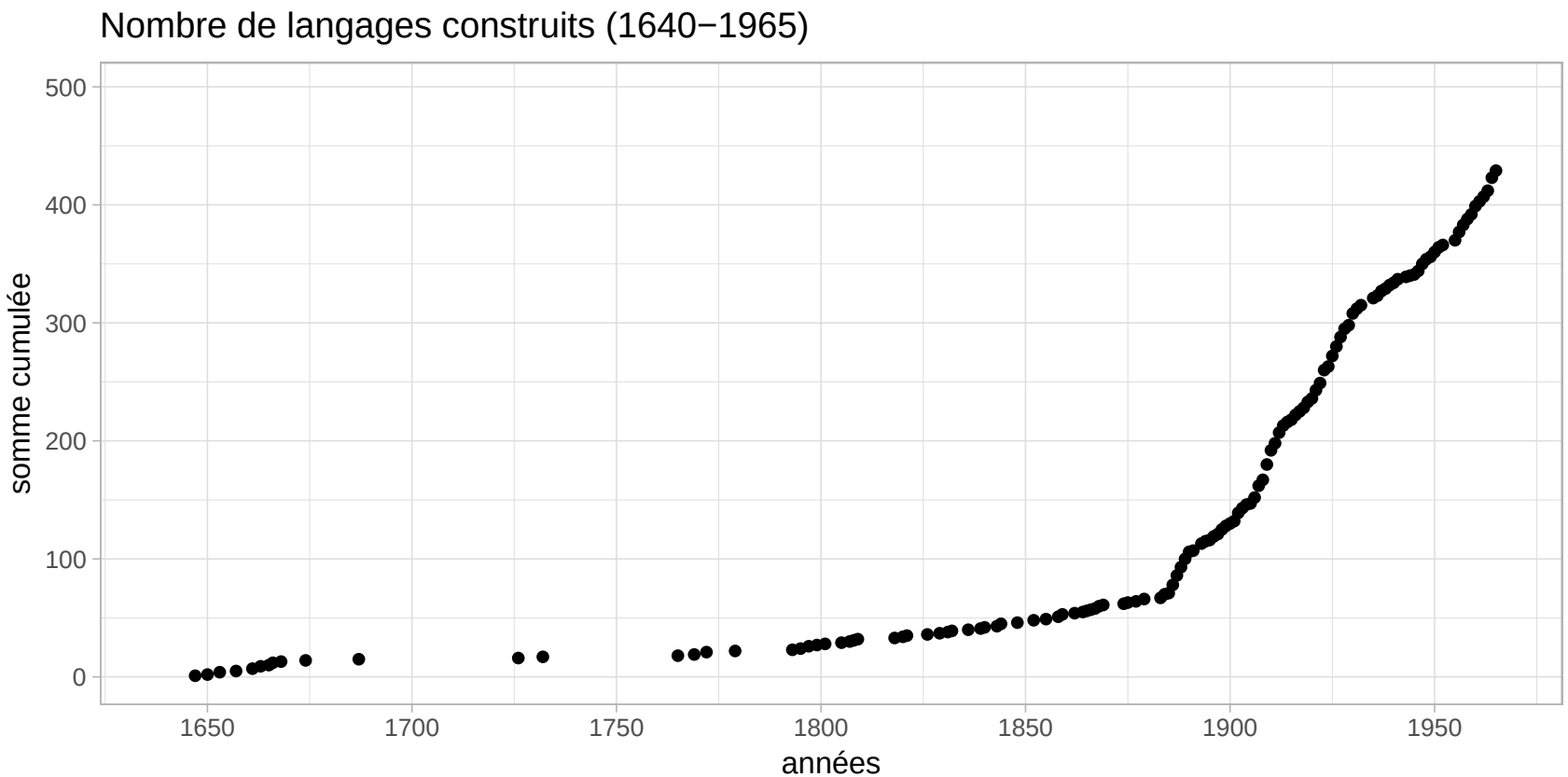
After WWII, growth of civil applications of technologies developed during the war, including (automated) computing.

Technology	Applications	
	military	civil
Nuclear	bombs	energy production dating ^{14}C
Automated computing	ballistics, etc.	numerical computing automatic translation information retrieval



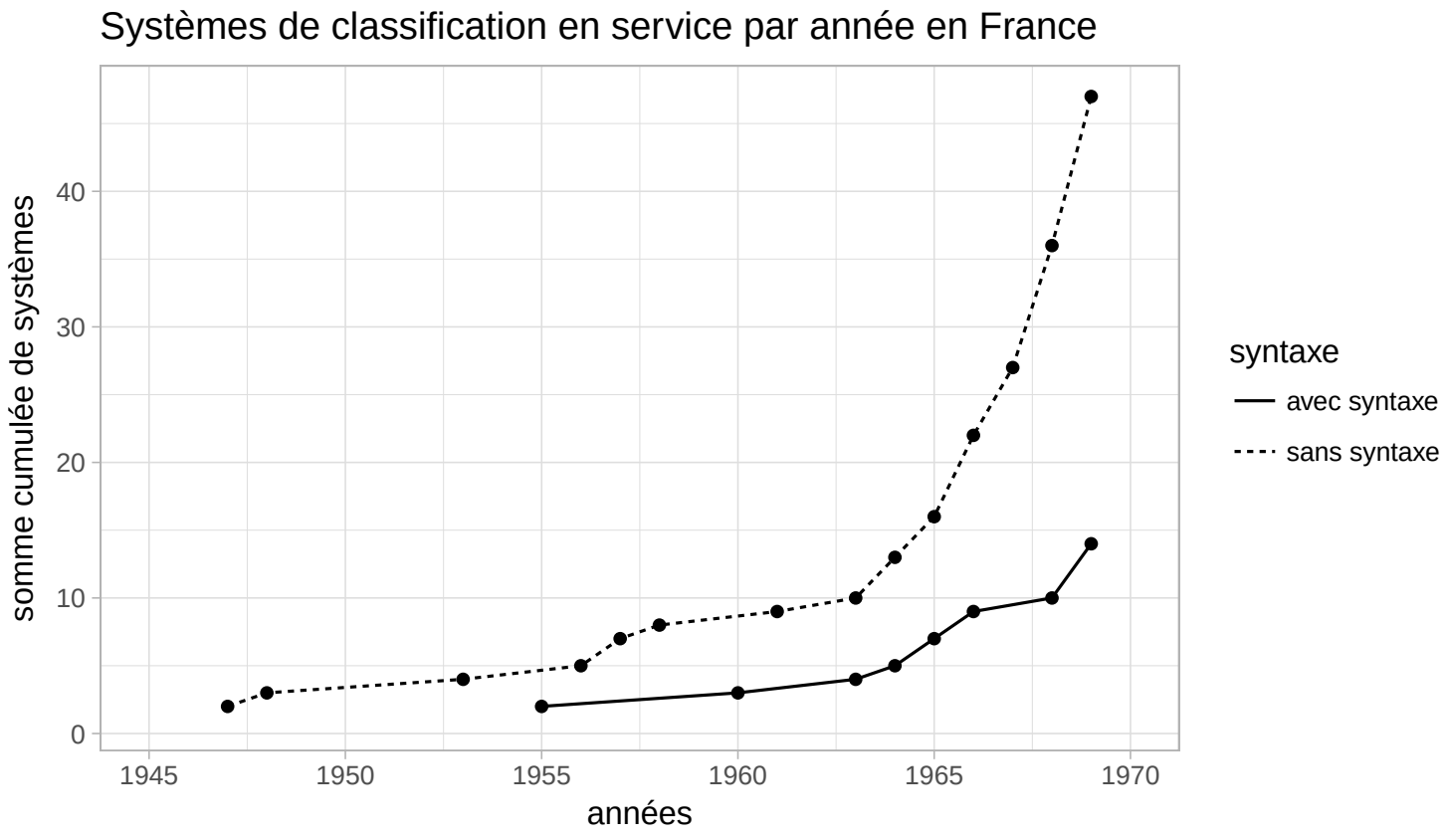
Cumulative annual sum of published constructed languages.

Data source: list of 500 languages from Okrent 2009. *In the Land of Invented Languages.Esperanto Rock Stars, Klingon Poest, Loglan Lovers, and the Mad Dreamers who Tried to Build a Perfect Language.*

A definition of "documentation language"

> *A documentary language is a tool for mediated communication, used for communication between humans and the authors of documents. In other words, a documentary language is a language that humans use when they want to access documents stored with other documents, in a given place, which can be variously defined. A documentary language is usually written and can be expressed as a diagram. It is not necessarily a [natural] language.*

Coyaud 1966. *Introduction à l'étude des langages documentaires.*, p. 17. My translation.



Cumulative annual sum of classification systems used in France (1945–70).

Hoppé and Lévy 1970. "Liste de quelques instruments de classification en France".

Key idea

- Early relations between archaeology and documentation systems.
- Jean-Claude Gardin and the SYNTOL (Syntagmatic Organization Language).

Gardin's activities in the field of (automated) documentation.

- Gardin 1955. "Problems of Documentation".
- Gardin 1956. *Le fichier mécanographique de l'outillage.Outils en métal de l'âge du bronze, des Balkans à l'Indus.*
- Gardin 1958. "Four Codes for the Description of Artifacts: An Essay in Archeological Technique and Theory".
- Gardin 1959. "On the Coding of Geometrical Shapes and Other Representations, with Reference to Archaeological Documents", International Conference on Scientific Information, Washington (D.C.), nov. 1958.

Gardin created and/or led many scientific organisations, related to:

- Automatic applications in the humanities and social sciences
- Computer science
- Automatic applications in archaeology
- Archaeology in Central Asia

Gardin created and/or led many scientific organisations, related to:

Automatic applications in the humanities and social sciences

- CADA: *Centre d'analyse documentaire pour l'archéologie*
- CCMSH: *Centre de calcul de la maison des sciences de l'homme*
- GEDSH: *Groupe d'études documentaires pour les sciences humaines*

Computer science

Automatic applications in archaeology

Archaeology in Central Asia

Gardin created and/or led many scientific organisations, related to:

Automatic applications in the humanities and social sciences

Computer science

- SAD: *Service d'automatique documentaire*
  (within the *Institut Blaise Pascal*, then the leading centre for computer science in France)

Automatic applications in archaeology

Archaeology in Central Asia

Gardin created and/or led many scientific organisations, related to:

Automatic applications in the humanities and social sciences

Computer science

Automatic applications in archaeology

- CMDA: Centre mécanographique de documen- tation archéologique
- RIDA: Réseau d'information et de documentation archéologiques

Archaeology in Central Asia

Gardin created and/or led many scientific organisations, related to:

Automatic applications in the humanities and social sciences

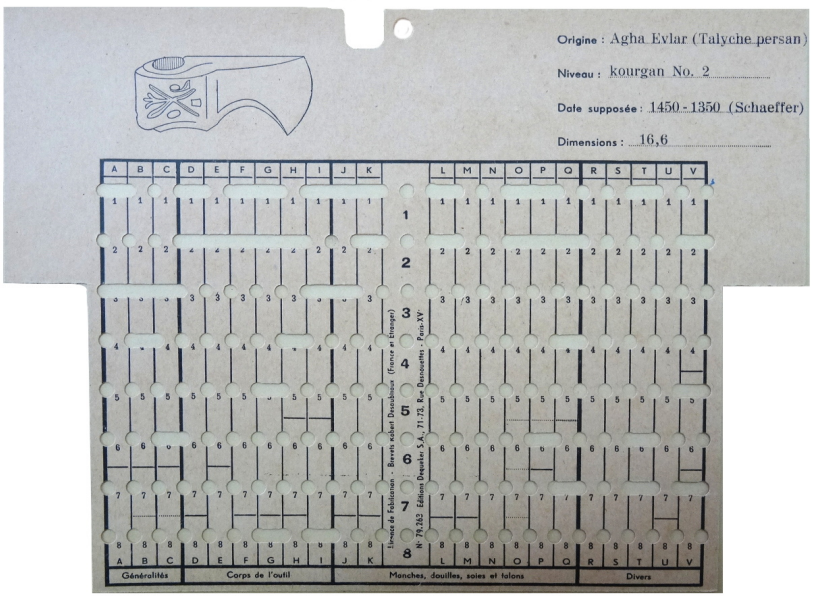
Computer science

Automatic applications in archaeology

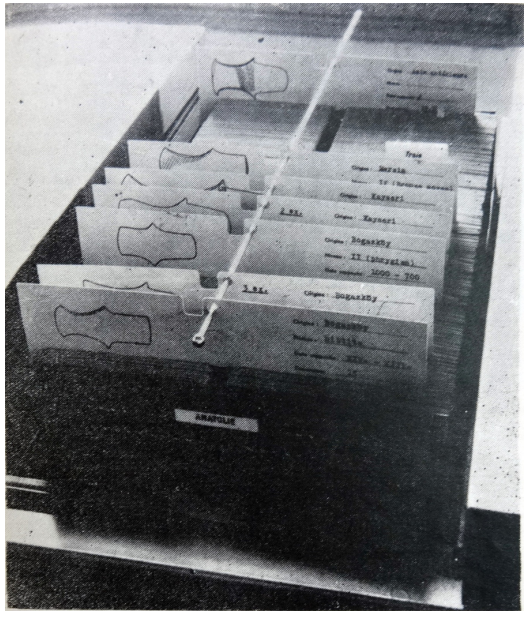
Archaeology in Central Asia

- CRA: *Centre de recherches archéologiques*
- Research group "Irrigation and settlement in Central Asia"
- Research group "Settlement of the Ancient Bactria"

Example 1: punched cards
The first (manual) data set on punched cards created by Gardin et al.



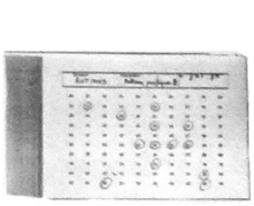
A punched-card from the oriental bronze objects data bank.



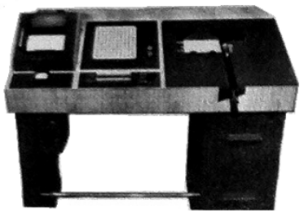
Selection device.

Gardin 1956. *Le fichier mécanographique de l'outillage.Outils en métal de l'âge du bronze, des Balkans à l'Indus.*

Production chain of a punched-cards data bank at the Cada:



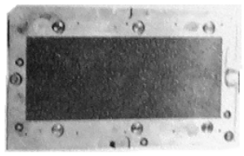
bordereau d'inversion des données



P.S. 5

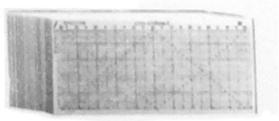
Carte « mère »

Unité de composition



Chassis transfert (C.T.)

Unité de reproduction



Cartes perforées (résultat)

(It includes a cards reproducer prototype.)

Formal codes to represent various types of material were created at the Cada:

Material objects

Iconography

Texts

Formal codes to represent various types of material were created at the Cada:

Material objects

1956 *Code pour l'analyse morphologique des Armes et Outils en métal* (1962).

1956 *Code pour l'analyse des formes de Poteries* (1976, 1985).

1969 *Code pour l'analyse des Monuments religieux* (1975, 1981).

Iconography

Texts

Formal codes to represent various types of material were created at the Cada:

Material objects

Iconography

1956 *Code pour l'analyse des Cylindres orientaux* (1975).

1960 *Code pour l'analyse des Documents graphiques.*

1961 *Code pour l'analyse des Films ethnographiques* (1975).

1956 *Code pour l'analyse des Ornements* (1978).

1965 *Code pour l'analyse des représentations figurées sur les vases grecs* (1980).

1967 *Code pour l'analyse des Mosaïques romaines.*

Texts

Formal codes to represent various types of material were created at the Cada:

Material objects

Iconography

Texts

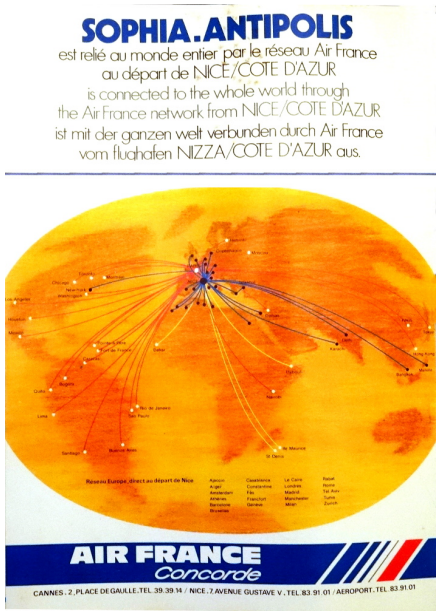
1958 *Code pour l'analyse des Textes orientaux* (1978).

1959 *Code pour l'analyse de la bibliographie de la Préhistoire.*

1963 *Analyse conceptuelle du Coran sur cartes perforées.*

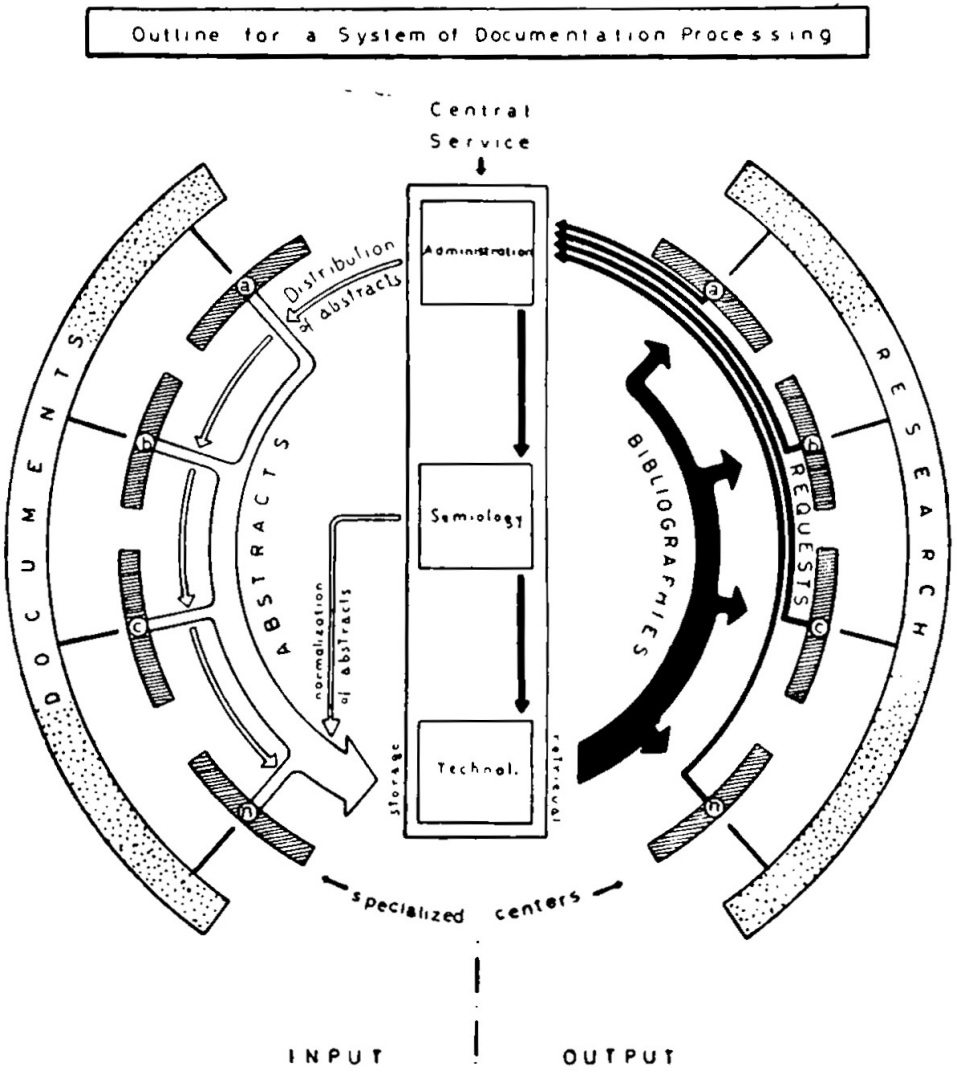
1969 *Code pour l'analyse de la bibliographie en Archéologie et Histoire romaines.*

Example 2: the Cra's documentation network
(*Centre de Recherches Archéologiques*, Valbonne, South of France)

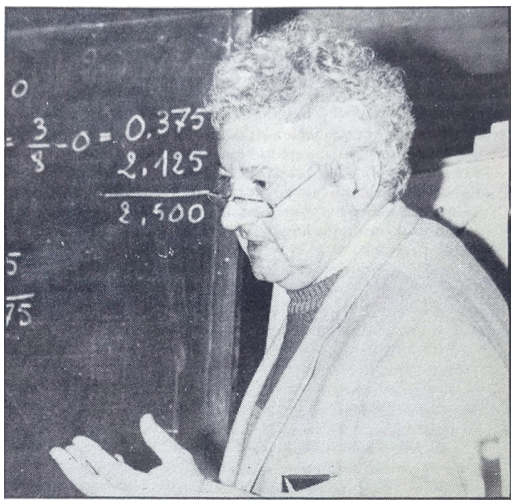


Advertisement about he "Sophia-Antipolis" technopole in the South of France

The Cra facilities, inaugurated in 1976 (here in 1984).



"*Outline for a System Documentation Processing*" : federative and non-centralised management of the scientific documentation. The central element includes an administrative service, a semiology service in charge to develop methods, and a technical service with programmers. Gardin 1962. "Proposals for the Coordination of Documentary Work in the Social Sciences", p. 29.



Jean Lesage
(1923–2004)

1923 Birth in Italy;

1935–1945 Resistance during WWII;

1957–1960 archaeological fieldwork in North Africa;

1964–1978 fieldwork South America

1973–1989 participation in Laplace's seminars;

1977 head of the computing service of the CRA, under Gardin's direction;

1978 head of the continuing education service of the CRA; organisation of many workshops on computer and mathematical applications in archaeology;

2004 death in France.

Lesage's action in brief

- Opposition to Gardin's large organisation and research program.
- Promote the education of archaeologists in mathematics and computer science rather than relying on proper computer scientists.
- Focus on teaching: organisation of numerous workshops and trainings, develop a personal reflection on pedagogy.
- Promote the use of personal computers rather than of mainframe computers available in large computing services.
- Create a library of programs and promote the sharing of codes.

Who do the computation?

- **distribution**: domain specialists ask external actor (formal approaches specialists) to perform the computations.
- **association**: computations are performed by domain specialists and formal approaches specialists, the last being integrated within the disciplinary structures.
- **specialisation**: (part of the) the domain specialists are trained enough in formal approaches to perform the computation by themselves.

Disciplinary dimension

Knowledge dimension

Social dimension

Material dimension

Disciplinary dimension

- Disciplinary framing:
  - Gardin: weak
  - CRA: strong
  - TA: medium
- Disciplinary level of action:
  - Gardin: transdisciplinary (humanities)
  - CRA: disciplinary (archaeology)
  - TA: subdisciplinary (prehistory)

Knowledge dimension

Social dimension

Material dimension

Disciplinary dimension

Knowledge dimension

- Relation between specialists:
  - Gardin: distribution
  - CRA: association
  - TA: specialisation
- Learning of formal skills by archaeologists:
  - Gardin: (by teaching)
  - CRA: teaching
  - TA: self-teaching

Social dimension

Material dimension

Disciplinary dimension

Knowledge dimension

- Formal skills:
  - Gardin: data bases, statistics
  - CRA: statistics
  - TA: statistics
- Teaching activity:
  - Gardin: few (occasional courses)
  - CRA: strong (trainings)
  - TA: medium (seminars)

Social dimension

Material dimension

Disciplinary dimension

Knowledge dimension

Social dimension

- Dependency to older scientific organisations:
  - Gardin: strong (positive)
  - CRA: strong (negative)
  - TA: weak
- Institution form:
  - Gardin: national research centres
  - CRA: research supporting services
  - TA: none (informal)

Material dimension

Disciplinary dimension

Knowledge dimension

Social dimension

- Social relations:
  - Gardin: professional, long-term
  - CRA: professional, short-term
  - TA: affinity, long-term
- Spatial organisation:
  - Gardin: multi-sites, network
  - CRA: decentralised, high mobility
  - TA: centralised (Arudy, Vitoria, Siena, Firenze)

Material dimension

Disciplinary dimension

Knowledge dimension

Social dimension

Material dimension

- Computing resources (external):
  - Gardin: computing centres (CIRCE, EURATOM, etc.)
  - CRA: no
  - TA: no
- Computing resources (internal):
  - Gardin: punched-card systems (prototypes)
  - CRA: hand-calculators, PC
  - TA: hand-calculators

Disciplinary dimension

Knowledge dimension

Social dimension

Material dimension

- Publishing formats:
  - Gardin: books, articles, datasets
  - CRA: software library, course material, journal
  - TA: articles, journal, datasets

Failure of the three models

What happened then?

Failure of the three models

- **Specialisation** (Laplace): the risk was that the specialised group was so specialised that he became apart of the rest of the disciplinary community;
- **Association** (Lesage, CRA): the risk was to dissolve the discipline's core practices (developing methods and programs for archaeologists still practising archaeology or computer science?)
- **Distribution** (Gardin): distribution secure the discipline's core practice; however the risk was that the disciplinary norms to be redefined by computer scientists and mathematicians.

What happened then?

Failure of the three models

What happened then?

- no development of a computer based-speciality in archaeology (in general, and in France in particular);
- growth of archaeometry (rather than "archaeo-computing")
- at the international scale: ongoing development of a "computational archaeology", whose epistemological status has still to be analysed, and archaeologists play their role in the growth of digital humanities.
- however, processes and issues similar to those studied here can be observed,
- in archaeology, and more generally, also in other disciplines (e.g. those impacted by the growth of "complexity science", "network science", "AI").

Thank you for your attention

sebastien.plutniak_at_posteo.net