Seriation (and Chronological Inference)

- Seriation is a set of ***methods*** designed to solve the problem of chronological inference.

- The methods are based ***models*** of how ***variable values*** tend to be distributed across ***units*** at successive points in time.

  - **Units:** things that can be inferred to be the results of events with restricted durations, *e.g.* artifacts, assemblages of artifacts.

  - **Variable values:** the values of variables that characterize the units, *e.g. size, shape, type frequency.*

- Methods specify ***procedures*** for ordering units along a single dimension, based on the distribution of the values across them.

- The procedures allow us to achieve an order of units that fits the model.

- In a particular case, the ordering of units is a "***chronological hypothesis***"

- **Occurrence Seriation:**

Units:	assemblages
Variables:	discrete (1/0)

- **Frequency Seriation**:

- Units:	assemblages
- Variables :	continuous (% frequency of “types”)

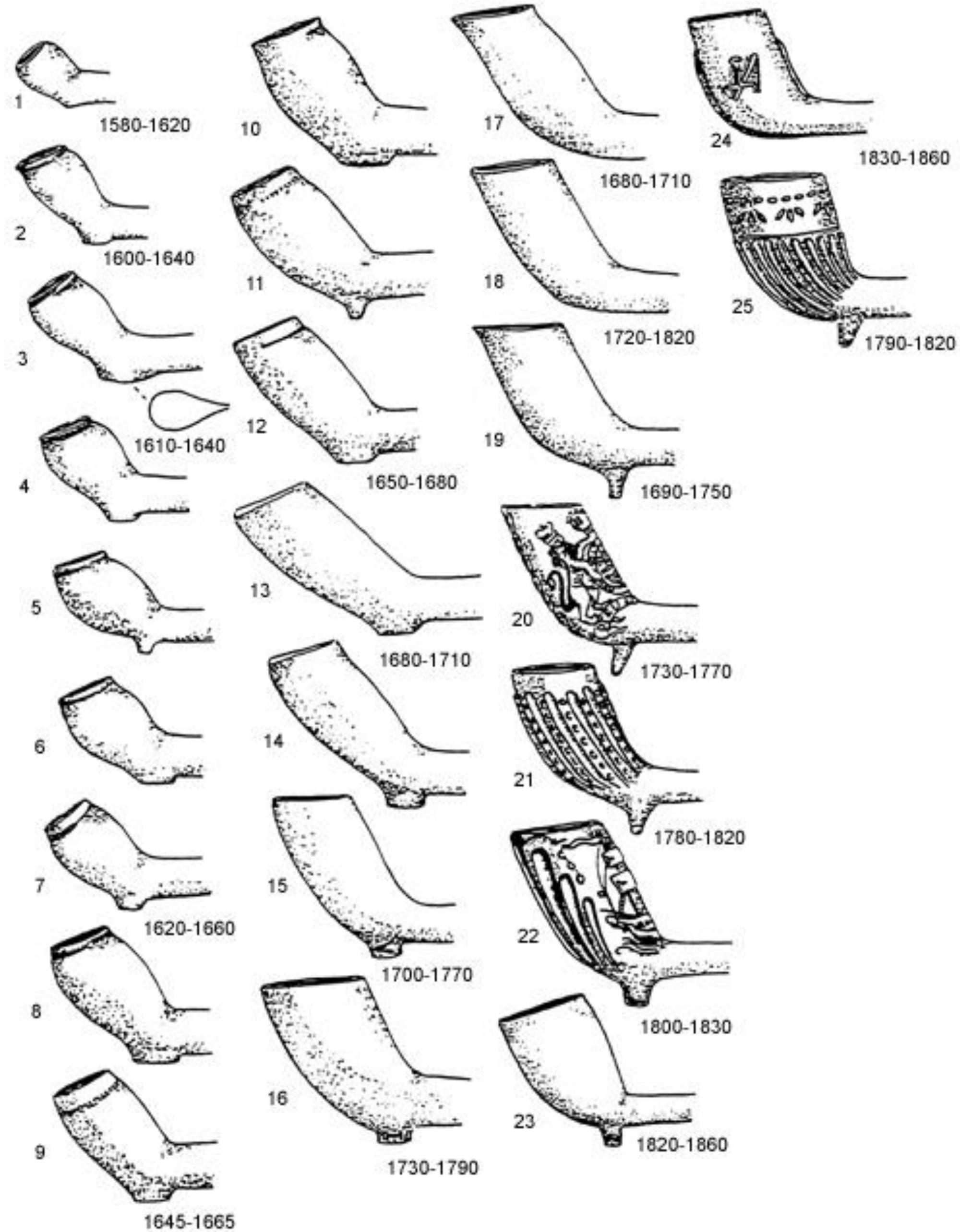
- **Phyletic Seriation:**

- Units:	artifacts or elements
- Variables:	discrete or continuous

Phyletic Seriation Model

- Objects that are close together in time are more similar, when similarity is measured on certain variables, than those that are far apart.

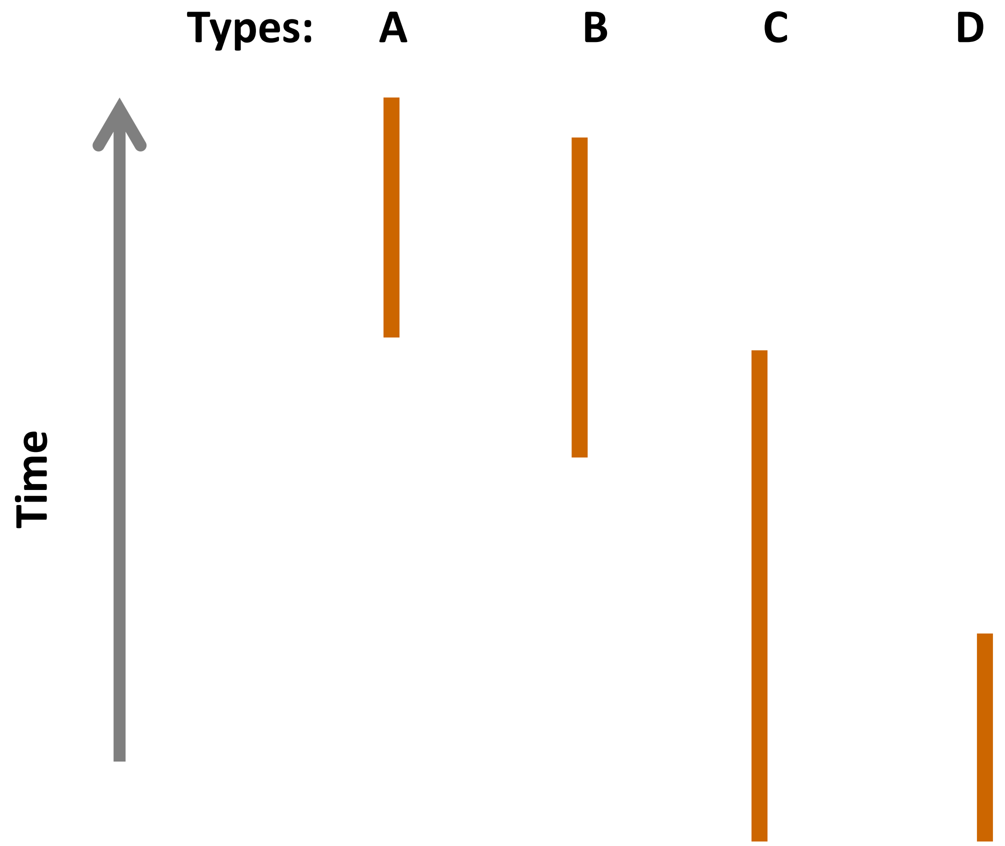
- Question: Which variables?



Occurrence Seriation Model

- The temporal distribution of types (characters) is continuous

- There is overlap in the temporal distribution of characters



Occurrence Seriation Method

- Given a set of units, characterized in terms of presence absence of attributes (types), the ordering of units that minimizes the number of absences among the presences is likely to be a chronology.
- "*the concentration principle*": minimize the number of gaps
- Question: Which variables (types)?

Occurrence Seriation

- Ugly raw data:

Units: \ Types:	D	B	A	C
2		1	1	
5	1			1
6	1			1
4		1		1
3		1	1	
1			1	

Occurrence Seriation

- Permute rows to minimize total number of gaps down columns.

Types:	D	B	A	C
Units:				
2		1	1	
5	1			1
6	1			1
4		1		1
3		1	1	
1			1	

Total Gaps = 5

Occurrence Seriation

- Permute rows to minimize total number of gaps down columns.

Units:	Types:	D	B	A	C
	1			1	
	2		1	1	
	3		1	1	
	4		1		1
	5	1			1
	6	1			1

Total Gaps = **0**

Occurrence Seriation

- Permute columns to minimize number of gaps across rows.

Types:

Units:

	D	B	A	C
1			1	
2		1	1	
3		1	1	
4		1		1
5	1			1
6	1			1

Total Gaps = **?**

Occurrence Seriation

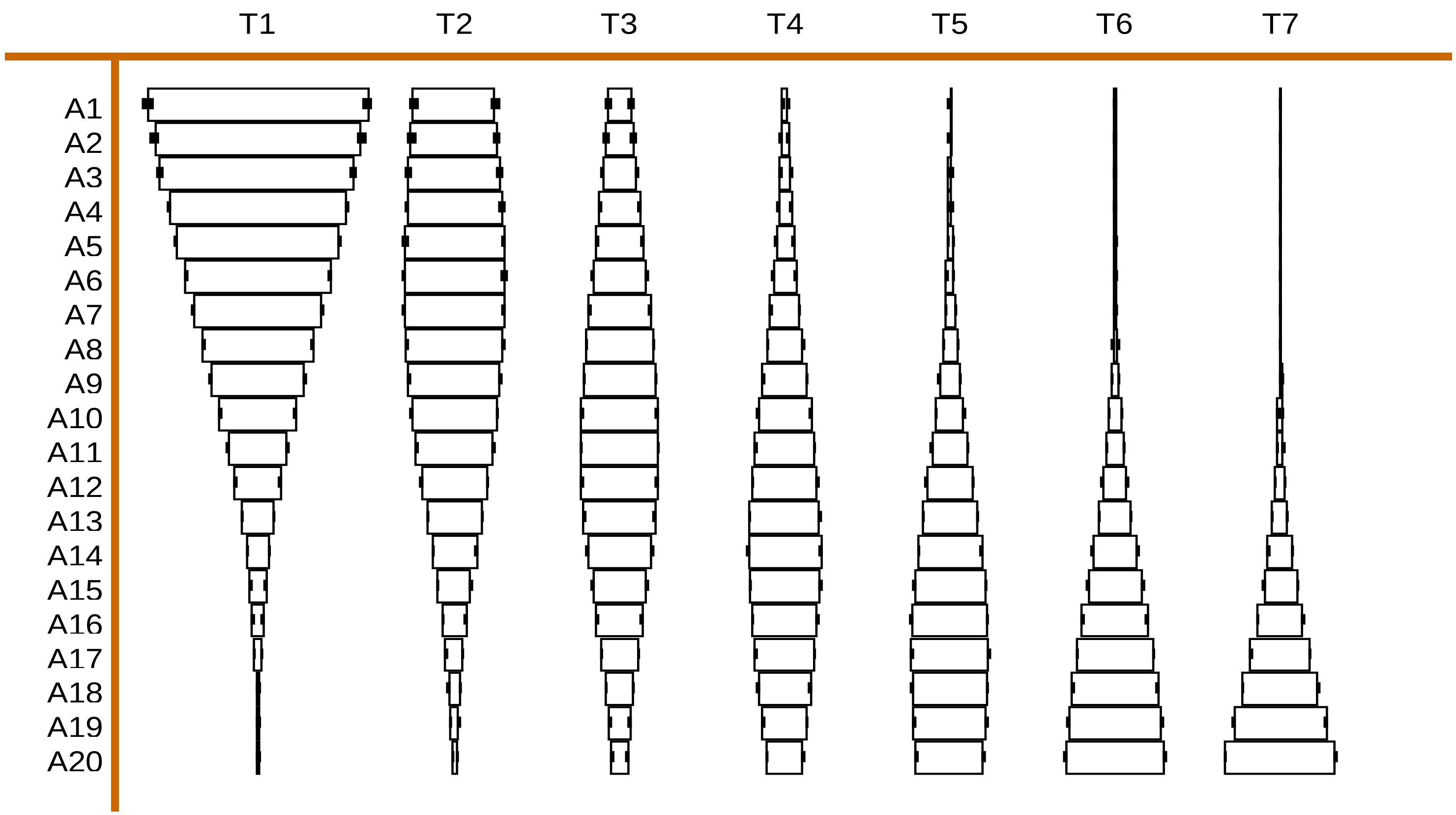
- Permute columns to minimize number of gaps across rows.

Units:	Types:	A	B	C	D
	1	1			
	2	1	1		
	3	1	1		
	4		1	1	
	5			1	1
	6			1	1

Total Gaps = **0**

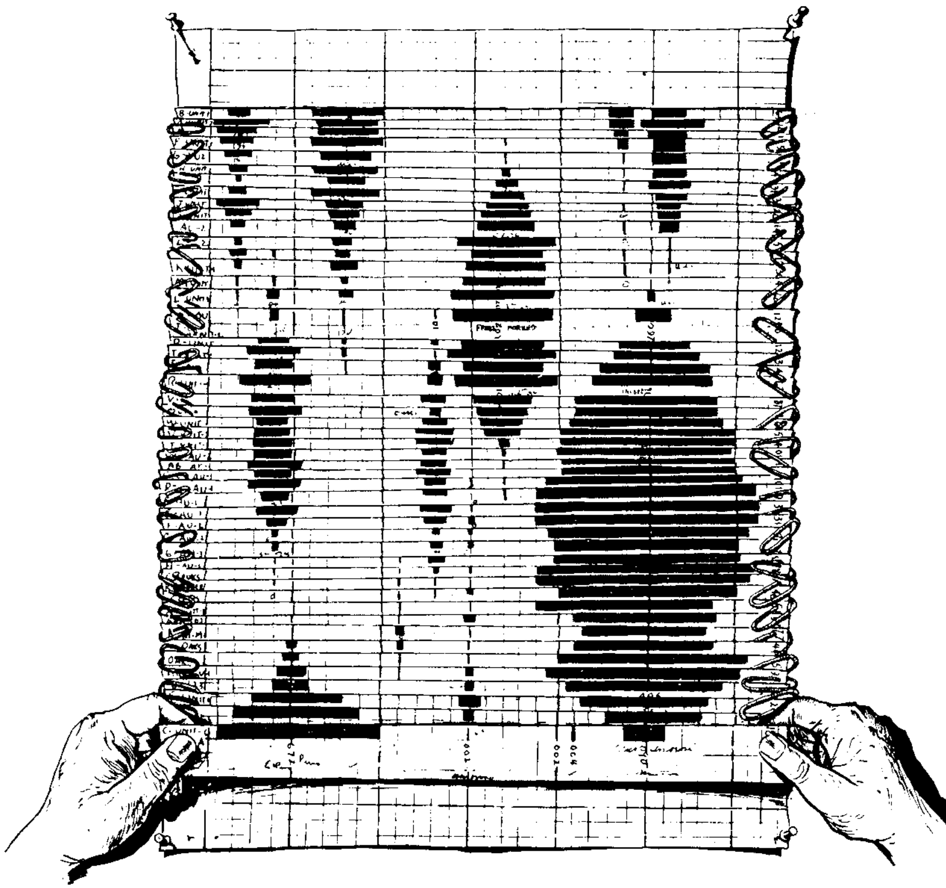
Frequency Seriation Model

- When the distributions of characters (types) are described in relative frequency terms, their shape in time tends to be lenticular or battleship-shaped.



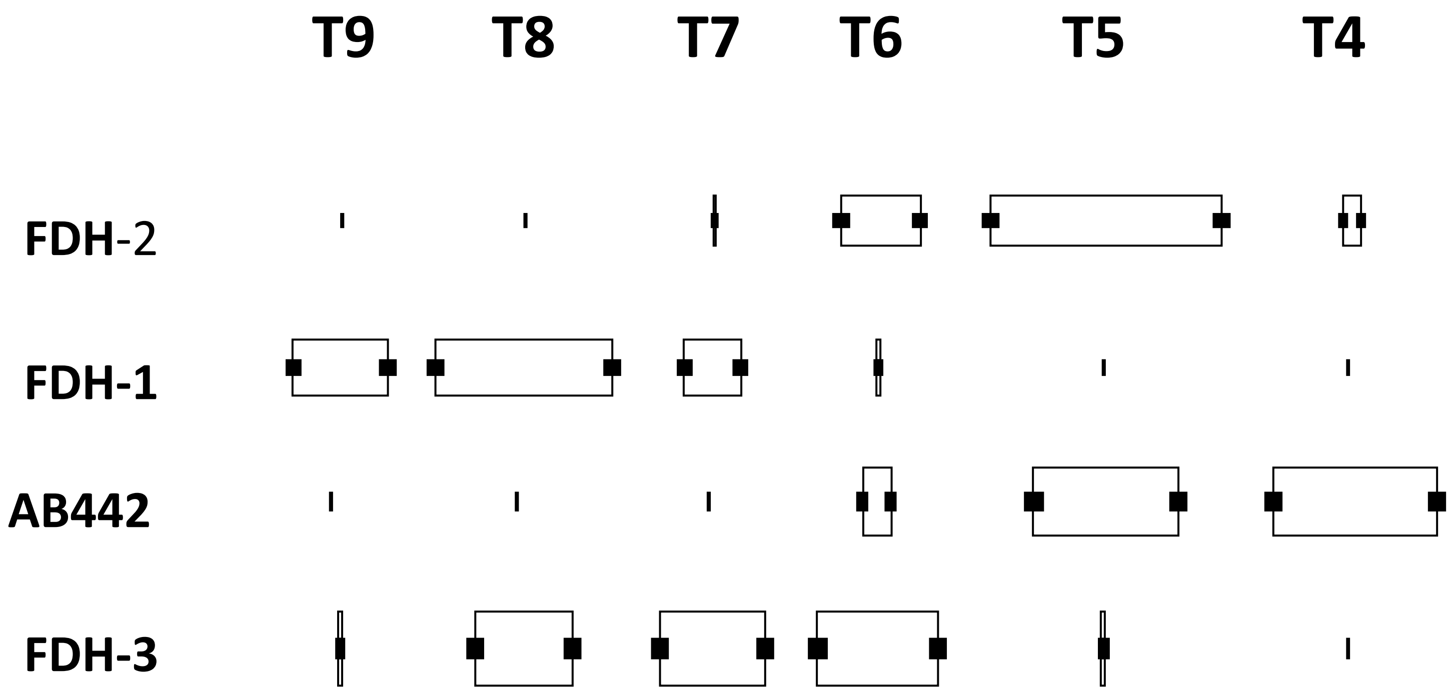
Frequency Seriation Method

- The ordering of units in which battleship-shaped distributions of types emerge is likely to be a chronology.
- Question: Which variables (types)?



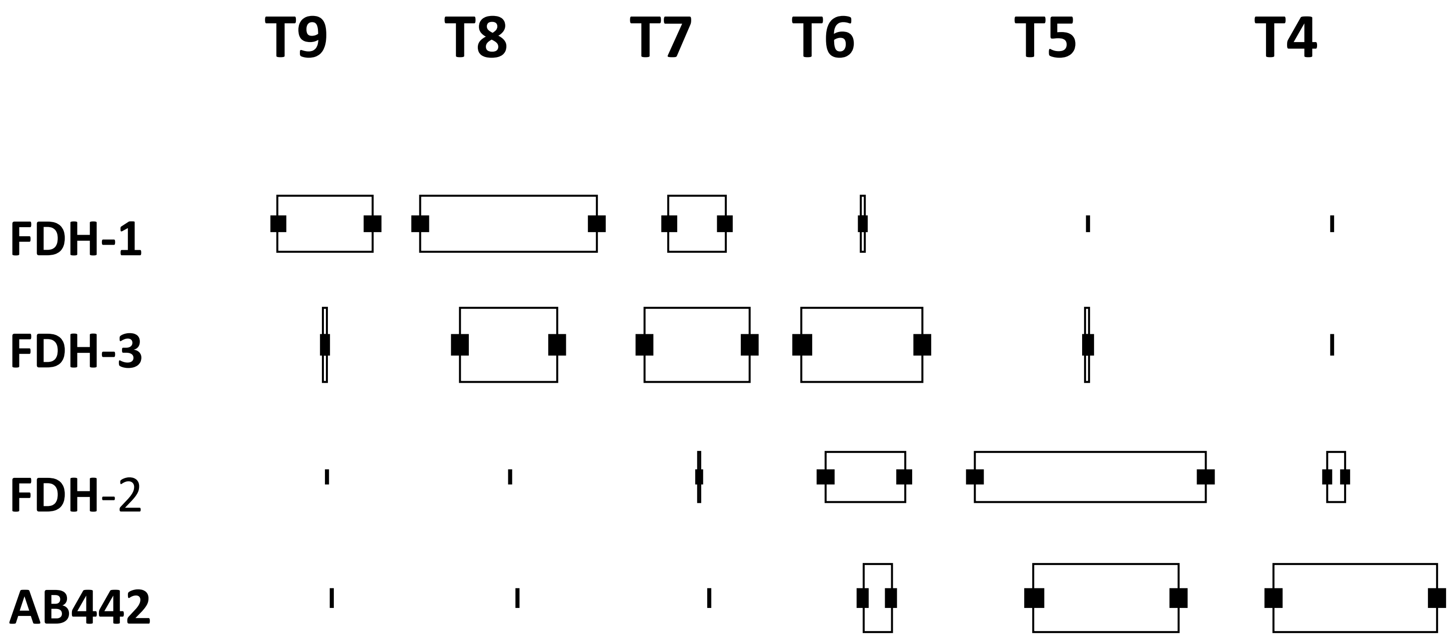
Frequency Seriation

- The ugly raw data



Frequency Seriation

- Permute the rows so that the battleship curves emerge.



Questions

- Which way is up?
- What is being dated?
- How can we check the order really is a chronology?

Conditions

1. Units have similar durations

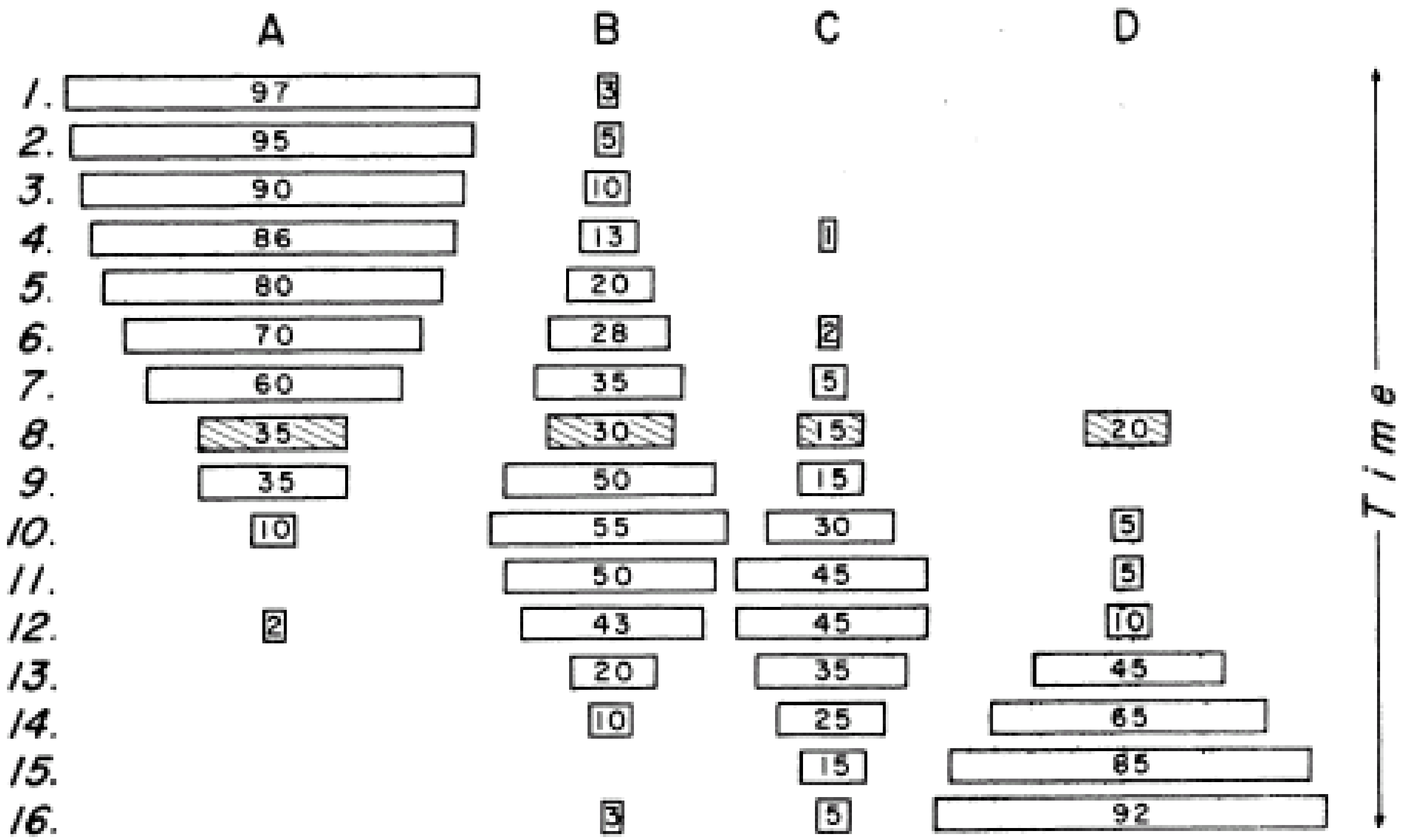


Fig. 3. The effect upon the seriation pattern of one group or unit not of comparable duration with the remainder of the included units. A-D are the classes, 1-16 are the groups of which 8 is the non-comparable unit.

Conditions

2. Units come from the same “cultural tradition”

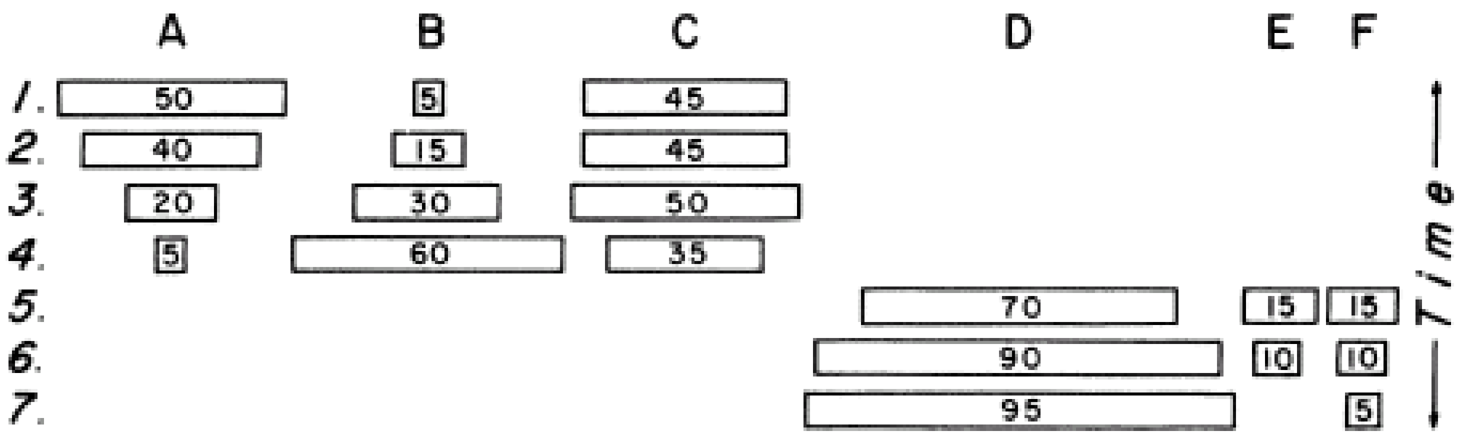


Fig. 4. Two independent orders resulting from the seriation of groups drawn from two different stylistic traditions. A - F are the classes and 1 - 7 are the groups. The placement of 5 - 7 at the bottom of the chart is arbitrary and they could have been placed at the top of the chart with equal justification.

3. Units come from the same “local area”.

"Same Local Area"

- *Deetz and Dethlefsen* show that different local areas (town cemeteries) show different patterns of battleship-shaped curves for grave-stone types.

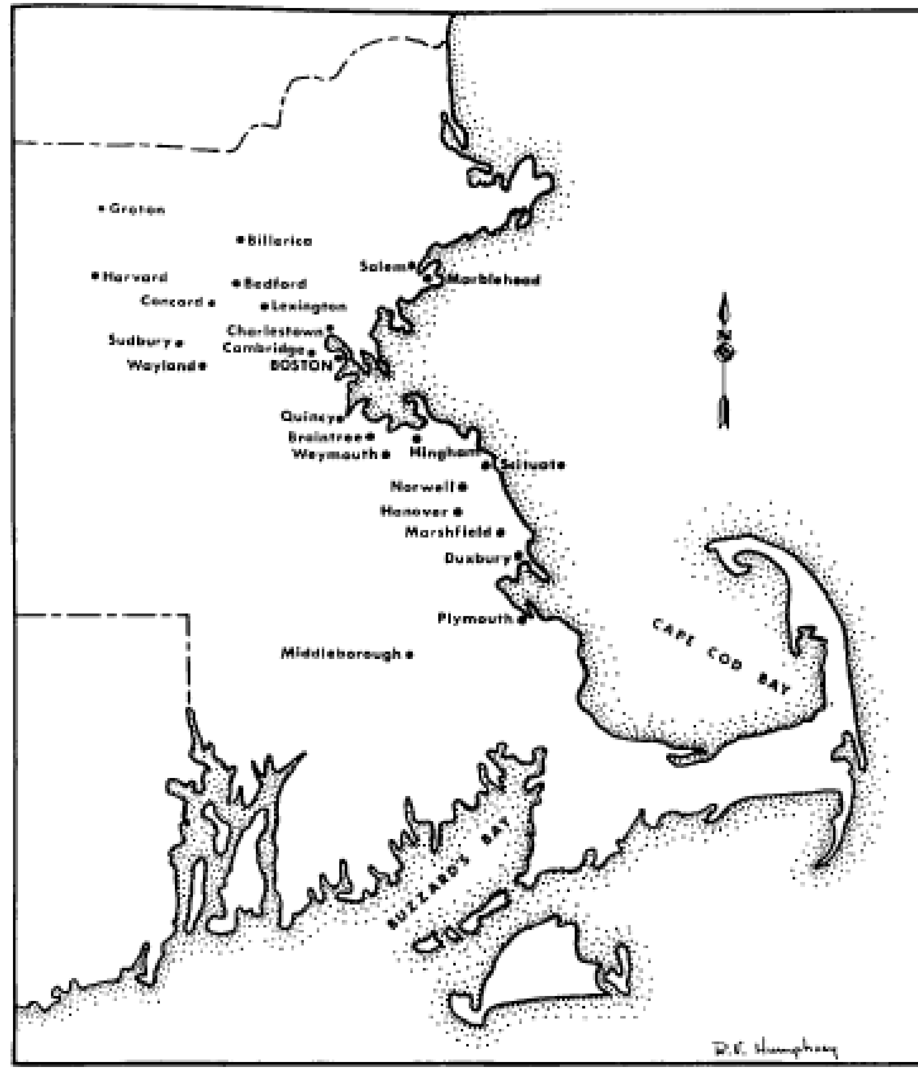


Fig. 1. Eastern Massachusetts, showing cemetery locations.

Source: Dethlefsen, E. and J. Deetz
1966 Death's heads, cherubs and Willow trees: experimental archaeology in colonial cemeteries. *American Antiquity* 31:502-510.

FIG. 2. Universal motifs. *a*, death's head; *b*, cherub; *c*, urn and willow.

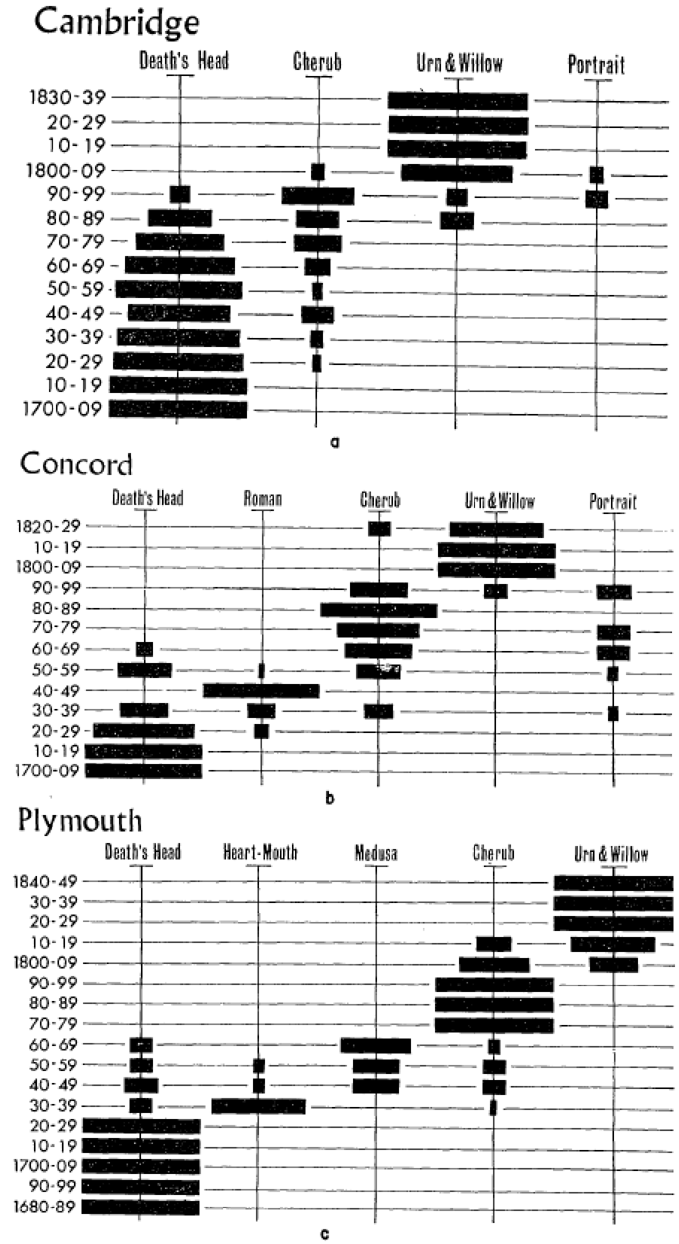


FIG. 3. Graphs showing stylistic sequences in three cemeteries.

"Same Local Area"

- Lipo *et al.* show that you can use the "local area" criterion to identify local areas – neighborhoods within which assemblages show the battleship-shaped curves for ceramic types – a single evolving tradition.

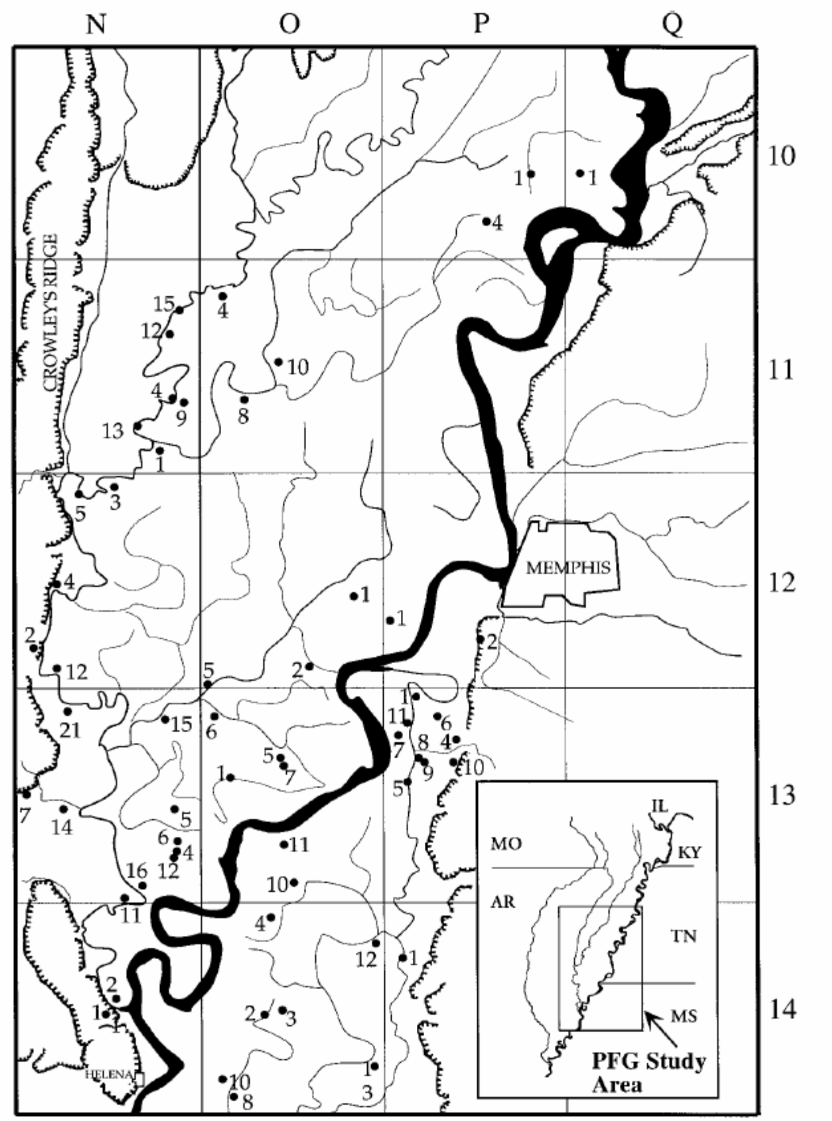


FIG. 9. Map of Lower Mississippi Valley Survey: Assemblages from the St. Francis and Mer regions from Phillips *et al.* (1951).

Source: Lipo, Carl P., Mark E. Madsen, Robert C. Dunnell, and Tim Hunt. 1997 Population structure, cultural transmission, and frequency seriation. *Journal of Anthropological Archaeology* 16 (4): 301-333.

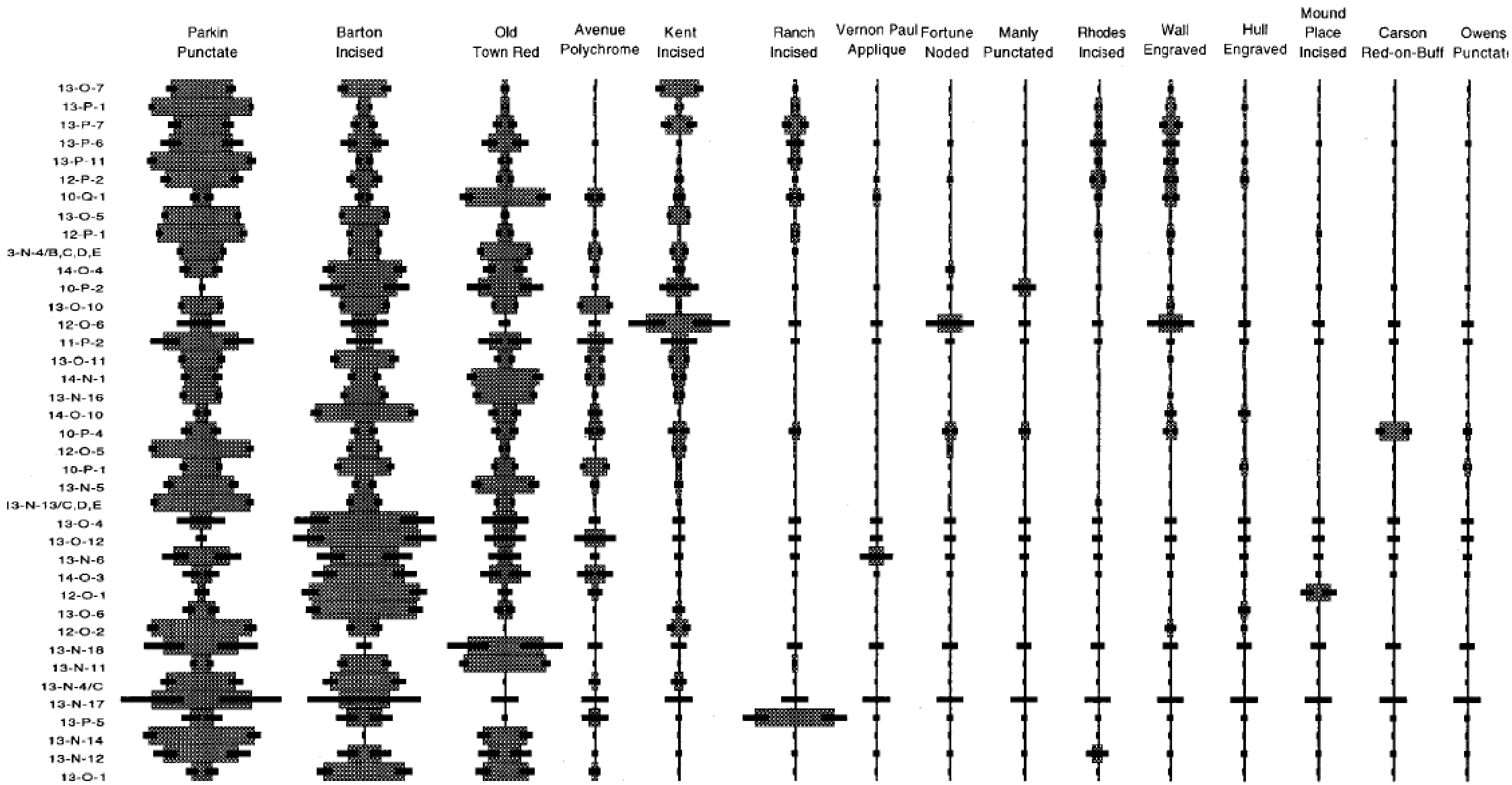


FIG. 11. Ford's seriation of the Memphis area data using only assemblages collected from the surface and decorated, shell tempered ceramic types. It is clear, that the neither the seriations in Fig. 10 nor Fig. 11 meet the expectations of the model.

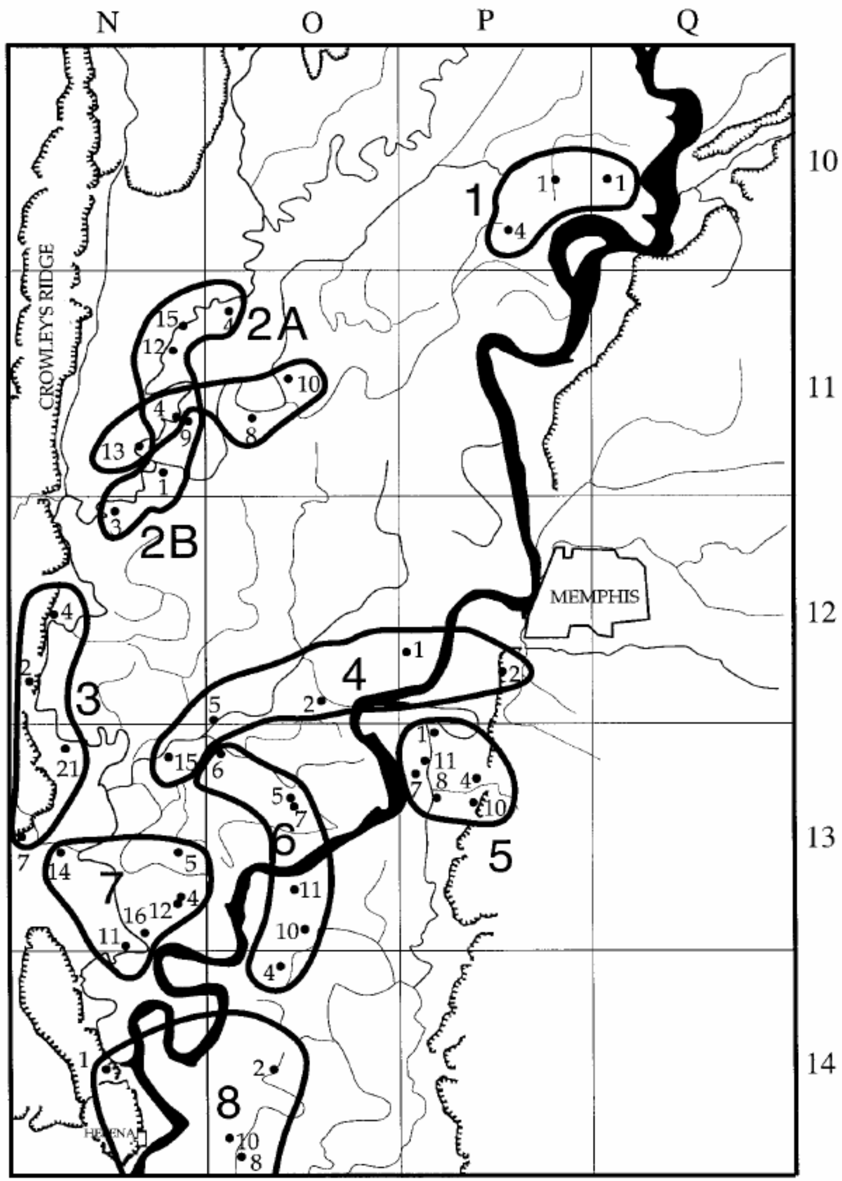
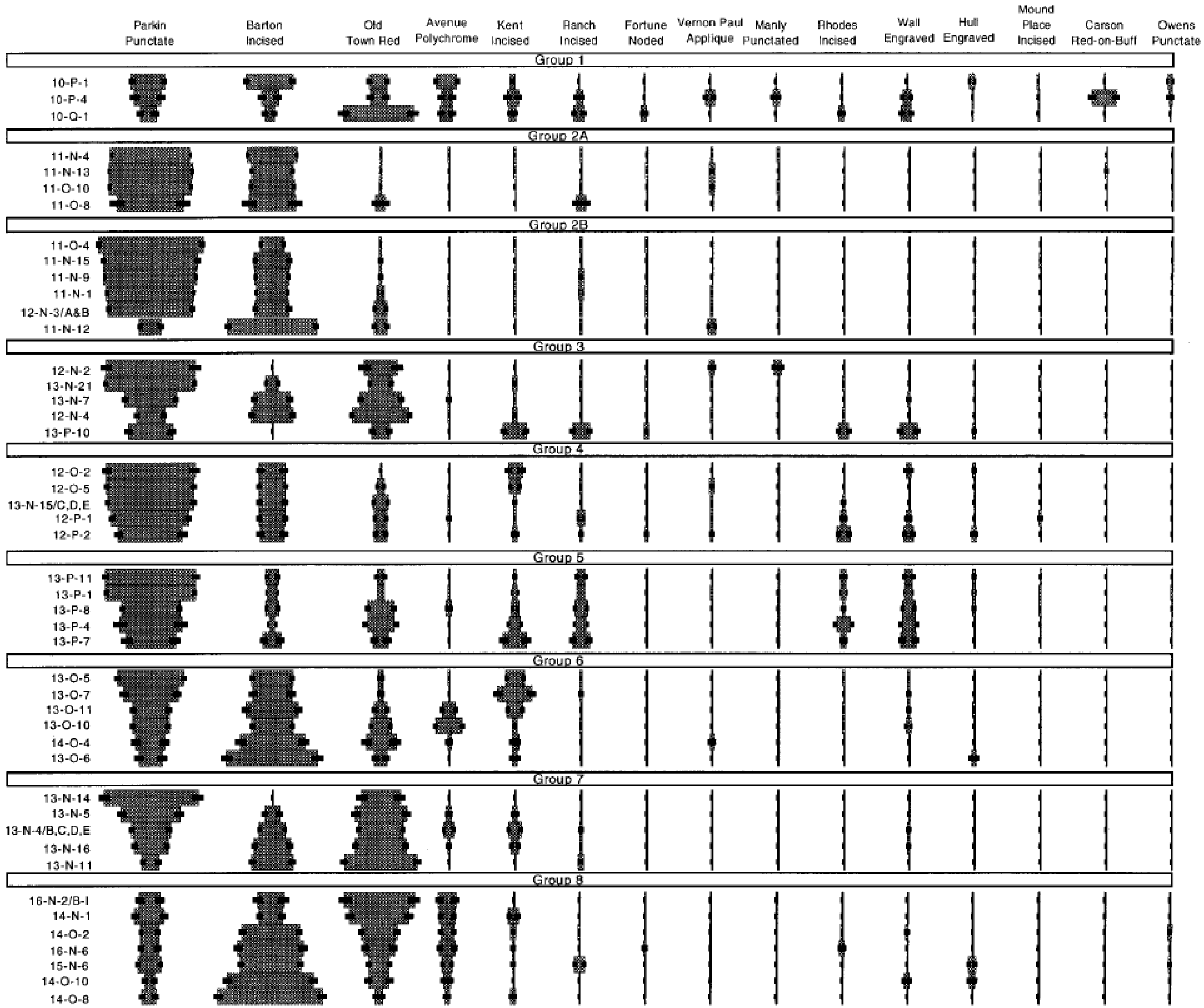


FIG. 13. Geographic distribution of solution clusters of all PFG assemblages. Numbers (1–8) refer to the seriation solutions from Fig. 12.



Parkin Punctate
Barton Incised
Old Town Red
Avenue Polychrome
Kent Incised
Rhanch Incised
Fortune Noded
Vernon Paul Applique
Manly Punctated
Rhodes Incised
Wall Engraved
Hull Engraved
Mound Place Incised
Carson Red-on-Buff
Owens Punctate
Group 1
10-P-1
10-P-4
10-Q-1
Group 2A
11-N-4
11-N-13
11-O-10
11-O-8
Group 2B
11-O-4
11-N-15
11-N-9
11-N-1
12-N-3/A&B
11-N-12
Group 3
12-N-2
13-N-21
13-N-7
12-N-4
13-P-10
Group 4
12-O-2
12-O-5
13-N-15/C,D,E
12-P-1
12-P-2
Group 5
13-P-11
13-P-1
13-P-8
13-P-4
13-P-7
Group 6
13-O-5
13-O-7
13-O-11
13-O-10
14-O-4
13-O-6
Group 7
13-N-14
13-N-5
13-N-4/B,C,D,E
13-N-16
13-N-11
Group 8
16-N-2/B-I
14-N-1
14-O-2
16-N-6
15-N-6
14-O-10
14-O-8

Conditions

4. No sampling issues.

Assemblages are large enough so that estimates of type proportions in them mirror actual type frequencies in the underlying population of sherds: *sampling error does not obscure patterns.*

5. Battleship-Shaped Curves Rule.

The underlying type frequencies really do have Battleship-Shaped curves. *They are "historical types"*

Frequency Seriation

Conditions

- Battleship curves ***if***
  - assemblages have similar durations.
  - assemblages from same local area and cultural tradition.
  - little sampling error
  - ”historical types” = battleship-shaped curves

Evaluation

- Goodness of fit to the model
  - Do the assemblages and types you have chosen seriate?
  - Evidence of discontinuity in the sequence?
  - Lack of fit is a learning opportunity!
- Agreement with independently derived chronological hypotheses
  - Does the order from one seriation match the order from a second seriation , based on independent data?
  - Does the order correlate with orders based on independent data and inde[endet models theoretical models? (e.g. 14C, dendrochronology, OSL, stratigraphy?

Type Fossils

- A second approach to chronological inference, based on artifacts.
- Assign units to periods of time, based on the presence/absence of types.
- ***Type dates must be known on other grounds***

Type Fossils

Creamware: 1760-1820

Pearlware: 1780-1830

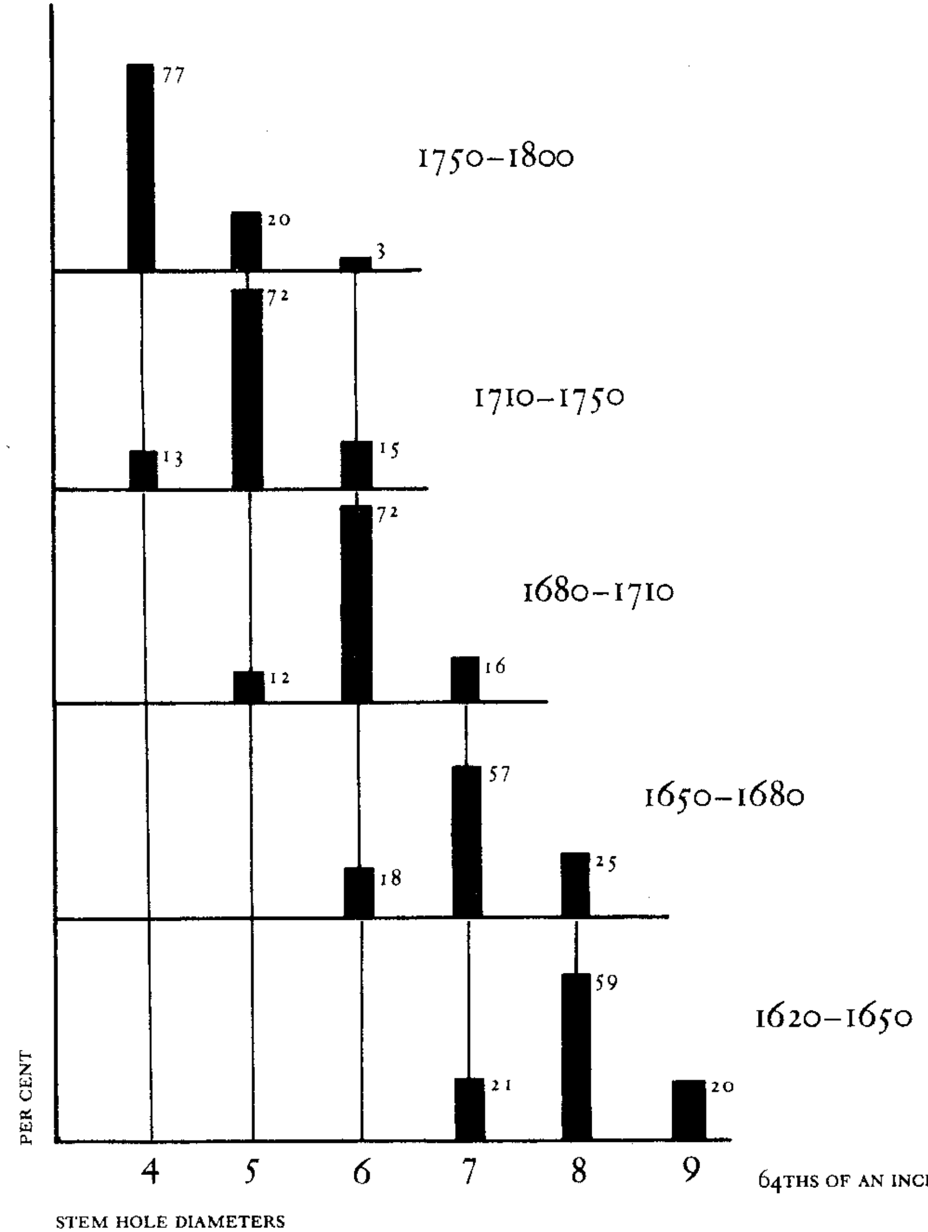
- *Terminus post quem* (TPQ): Date after which
- *Terminus ante quem* (TAQ): Date before which

Hybrid Methods

- pipestem dating
- mean ceramic dating
  used in historical archaeology (and the Southwestern US)

Pipestem Dating

Harrington histograms



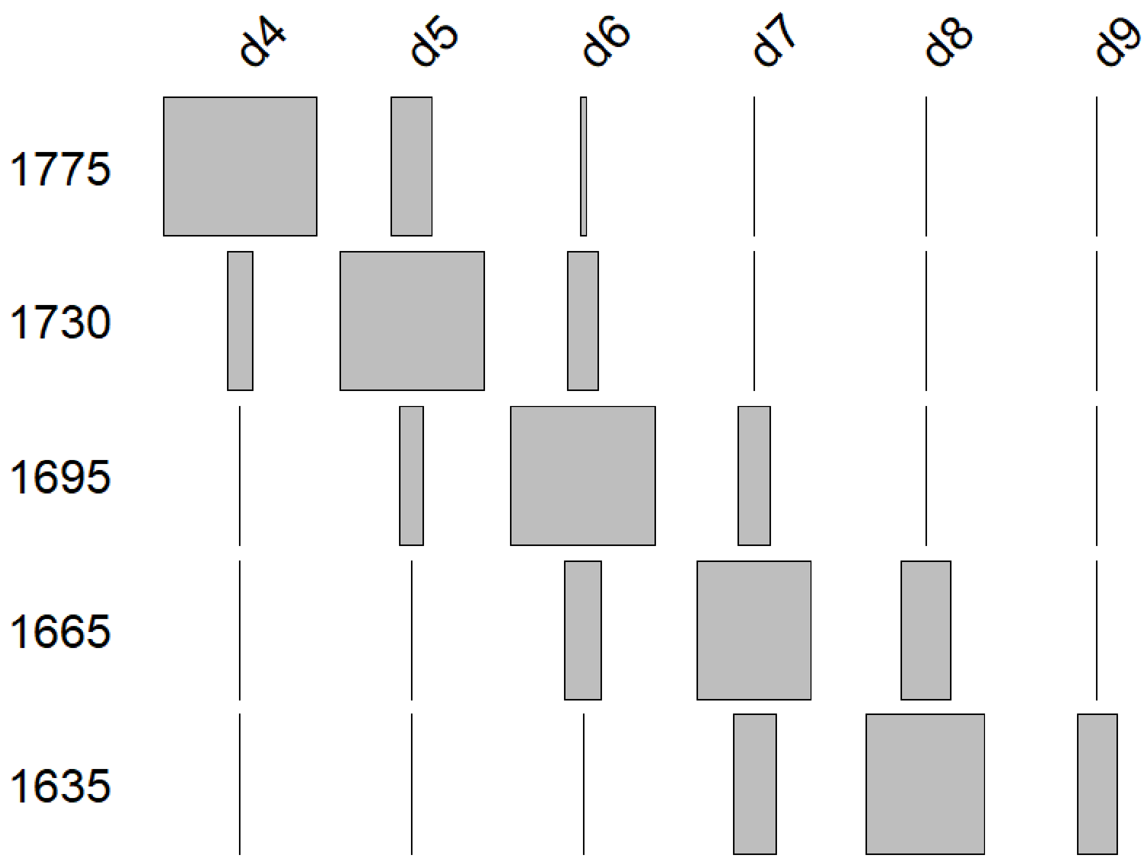
Source:

Harrington, JC

1954 Dating stem fragments of 17th and 18th century tobacco pipes. *Quarterly Bulletin of the Archaeological Society of Virginia*

Pipestem Dating

Harrington histograms … transposed!



Harrington Histograms → Mean Bore Diameters

$$\bar{x} = \frac{\sum_{i=1}^{n} f_i i}{\sum_{i=1}^{n} f_i}$$

1. The Data

Median Date	4	5	6	7	8	9	Total
1775	77	20	3	0	0	0	100
1730	13	72	15	0	0	0	100
1695	0	12	72	16	0	0	100
1665	0	0	18	57	25	0	100
1635	0	0	0	21	59	20	100

2. Products

1775	308	100	18	0	0	0
1730	52	360	90	0	0	0
1695	0	60	432	112	0	0
1665	0	0	108	399	200	0
1635	0	0	0	147	472	180

3. Sum of Products

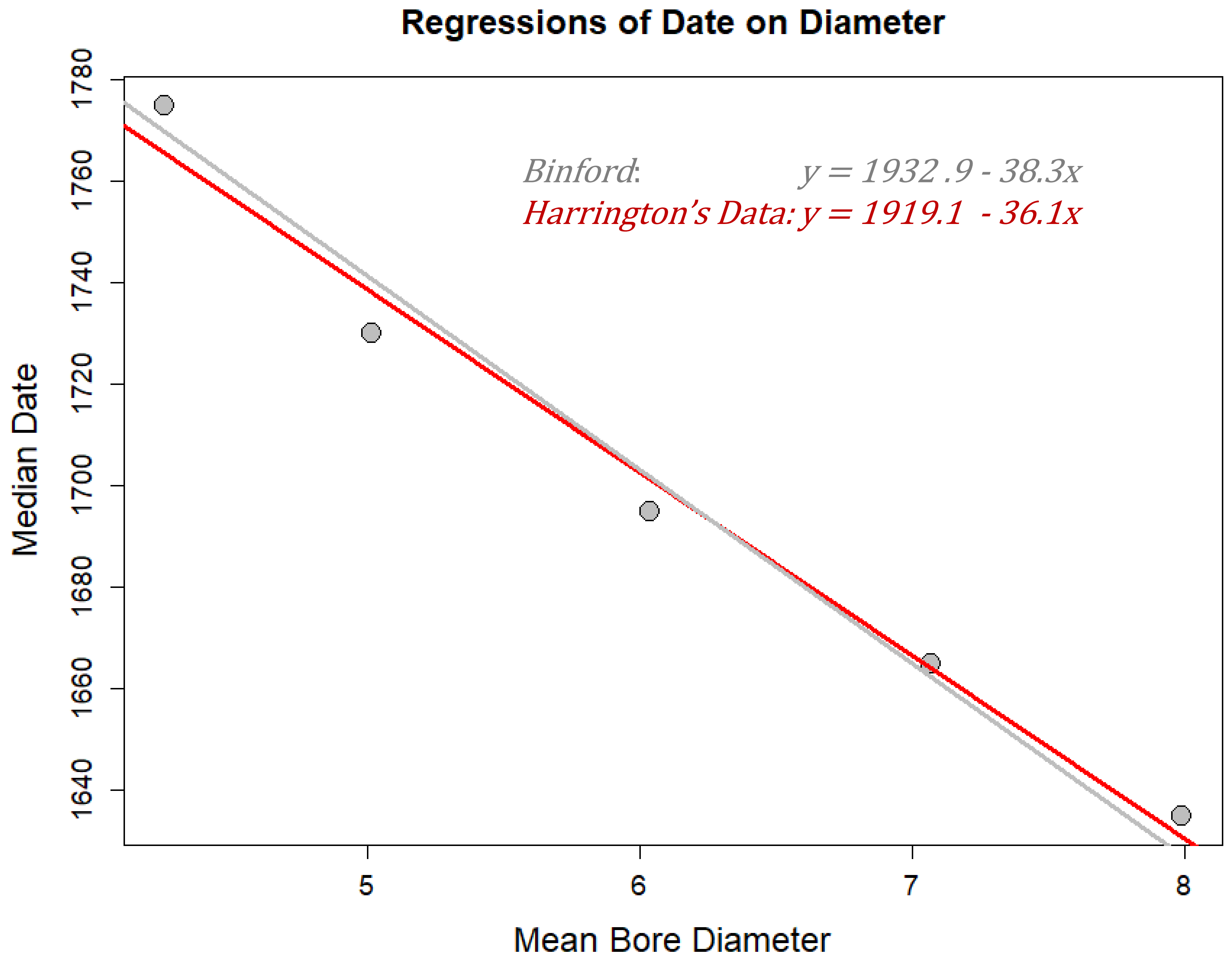
1775	426
1730	502
1695	604
1665	707
1635	799

4.Mean Bore Diameter

1775	**4.26**
1730	**5.02**
1695	**6.04**
1665	**7.07**
1635	**7.99**

i = 1 through n indexes the bore diameter class values (*e.g.* 2,3,4,5,6,…./64th inch)

$f_i =$ the frequency (count) for the *i'th* class



Regressions of Date on Diameter
Binford: y = 1932 .9 - 38.3x
Harrington's Data: y = 1919.1 - 36.1x
Median Date
Mean Bore Diameter
1640
1660
1680
1700
1720
1740
1760
1780
5
6
7
8

Mean Ceramic Dating

$$\bar{x} = \frac{\sum_{i=1}^{n} f_i m_i}{\sum_{i=1}^{n} f_i}$$

$i = 1$ through n indexes the ware type classes.

$f_i =$ the frequency (count) for the $i'th$ ware type.

$m_i =$ manufacturing midpoint for the i'th ware type

1. The Data

Type:	**Creamware**	**Delft**	**Pearlware**	**WhiteSaltGlaze**	**Total**
Median Date:	**1790**	**1750**	**1805**	**1760**	
Dry Well	666	0	0	169	835
Site7	331	90	51	46	518
Bldg.O	492	40	89	36	657
House	102	8	75	2	187
Bldg.T	326	21	156	26	529

2. Products

Dry Well	1192140	0	0	297440
Site7	592490	157500	92055	80960
Bldg.O	880680	70000	160645	63360
House	182580	14000	135375	3520
Bldg.T	583540	36750	281580	45760

3. Sum of Products

Dry Well	1489580
Site7	923005
Bldg.O	1174685
House	335475
Bldg.T	947630

4. MCD

Dry Well	**1783.9**
Site7	**1781.9**
Bldg.O	**1788.0**
House	**1794.0**
Bldg.T	**1791.4**

Source:

South, Stanley

1972 Evolution and Horizon as Revealed in Ceramic Analysis in Historical Archaeology. *Conference on Historic Site Archaeology Papers* 6:71-116.


First Roundabout
Kitchen Yard
Stable
Quarters
Mulberry Row
Stone Workman's House
Quarter
1809 Stone House
Smokehouse
Storehouse
Nailery
Smith's Shop
Garden Pavilion
Joinery
Carpenter's Shop
Second Roundabout
Third Roundabout
790-868
720-790
650-720
Elevation (Feet)
N
W
E
S
0
500
Feet

MCDs for Monticello Sites

Type	Cr	CrOverg	CrTrans	Delft	Pe	PeAnnul	PeFlow	PeHandp	PeMocha	PePoly	PeShell	PeSpong	PeTrans	PoHandp	PoOverg	StWhite
Median Date	**1790**	**1790**	**1790**	**1750**	**1805**	**1805**	**1860**	**1800**	**1843**	**1805**	**1805**	**1888**	**1818**	**1785**	**1770**	**1760**
Dry Well	666	0	0	0	0	0	0	0	0	0	0	0	0	25	197	169
Site7	331	0	0	90	51	7	0	10	0	1	4	0	2	18	1	46
Bldg.O	492	7	2	40	89	11	1	76	2	16	27	0	33	224	124	36
House	102	0	1	8	75	1	2	53	1	11	12	0	54	108	61	2
Bldg.T	326	1	1	21	156	15	0	87	5	75	45	1	113	127	63	26
SmokeH	467	66	0	0	57	2	0	99	28	157	94	0	358	267	202	65
Bldg.R	236	3	1	4	185	14	3	95	4	43	29	8	59	151	48	2
Bldg.L	181	3	0	3	98	4	0	59	3	54	29	0	126	81	59	7
Stewart	286	3	15	0	135	15	0	86	0	340	47	0	1	63	20	0
Bldg.S	402	2	1	12	541	41	0	229	3	167	118	8	340	275	153	14
BH	116	18	0	0	360	4	0	82	0	43	55	0	1	85	0	1
Kitchen	332	0	0	16	1199	130	23	256	19	117	180	76	1218	634	211	5

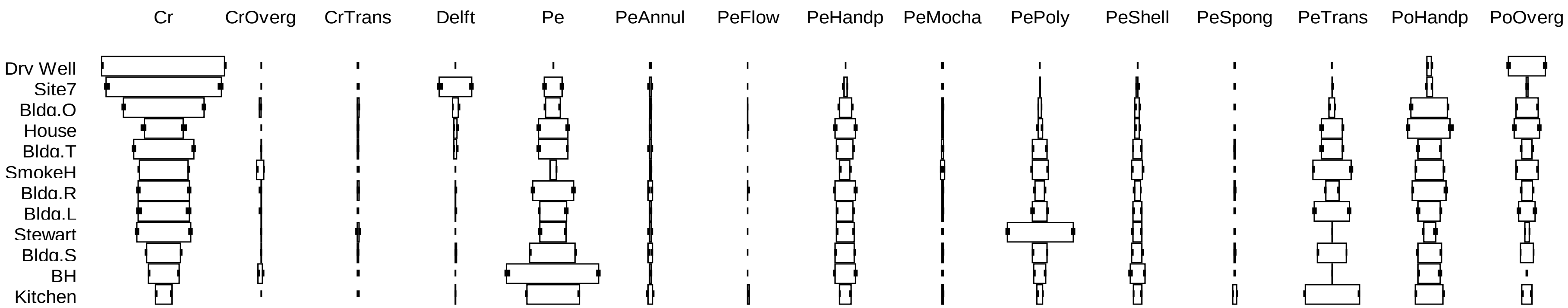
Site	**MC Date**
Dry Well	1781.4
Site7	1782.9
Bldg.O	1788.1
House	1793.2
Bldg.T	1794.9
SmokeH	1795.3
Bldg.R	1796.7
Bldg.L	1797.3
Stewart	1798.1
Bldg.S	1798.9
BH	1799.6
Kitchen	1804.3

Problems with the MCD and Pipe stem Formulas?

Problems with the MCD and Pipestem Formulas

- they are formulaic!
  - no matter what the data look like, you can always get an answer.
  - no indication if the solution fits the seriation model!

The Solution



- Sort the assemblages in their MCDs and plot the resulting seriation diagram: do you see the battleship-shaped curves?

- Do two seriations and compare the results: do they agree?

    - pipestem bore diameter seriation order vs. ceramic seriation order

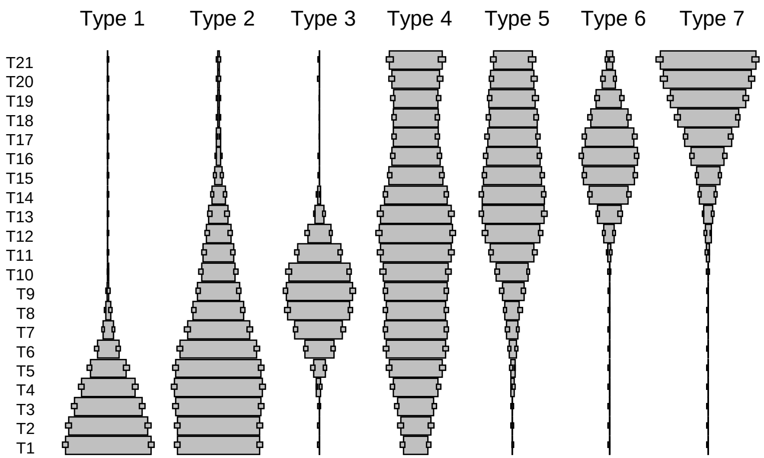
    - ratio of wrought /cut nails *vs.* ceramics seriation order

Correspondence Analysis

1. Iteration 1					
Type:	**Creamware**	**Delft**	**Pearlware**	**WhiteSaltGlaze**	**Scores**
Random Numbers:	**0.273366978**	**0.760887**	**0.92061152**	**0.164707505**	
Dry Well	0.80	0.00	0.00	0.20	***0.251375***
Site7	0.64	0.17	0.10	0.09	***0.412147***
Bldg.O	0.75	0.06	0.14	0.05	***0.384773***
House	0.55	0.04	0.40	0.01	***0.552651***
Bldg.T	0.62	0.04	0.29	0.05	***0.47825***
2. Iteration 2	***1.348169562***	***0.137663***	***0.45538671***	***0.137976796***	
Dry Well	0.80	0.00	0.00	0.20	
Site7	0.64	0.17	0.10	0.09	
Bldg.O	0.75	0.06	0.14	0.05	
House	0.55	0.04	0.40	0.01	
Bldg.T	0.62	0.04	0.29	0.05	
3. Iteration 3					
Dry Well	0.80	0.00	0.00	0.20	***1.103232***
Site7	0.64	0.17	0.10	0.09	***0.942482***
Bldg.O	0.75	0.06	0.14	0.05	***1.087218***
House	0.55	0.04	0.40	0.01	***0.925372***
Bldg.T	0.62	0.04	0.29	0.05	***0.977357***

Correspondence Analysis

1



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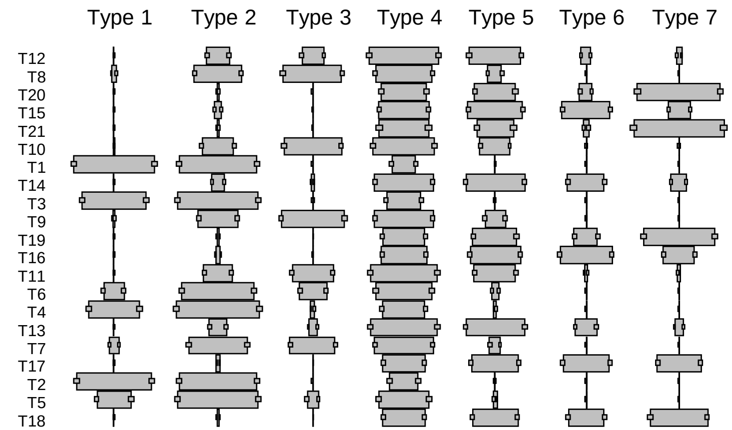

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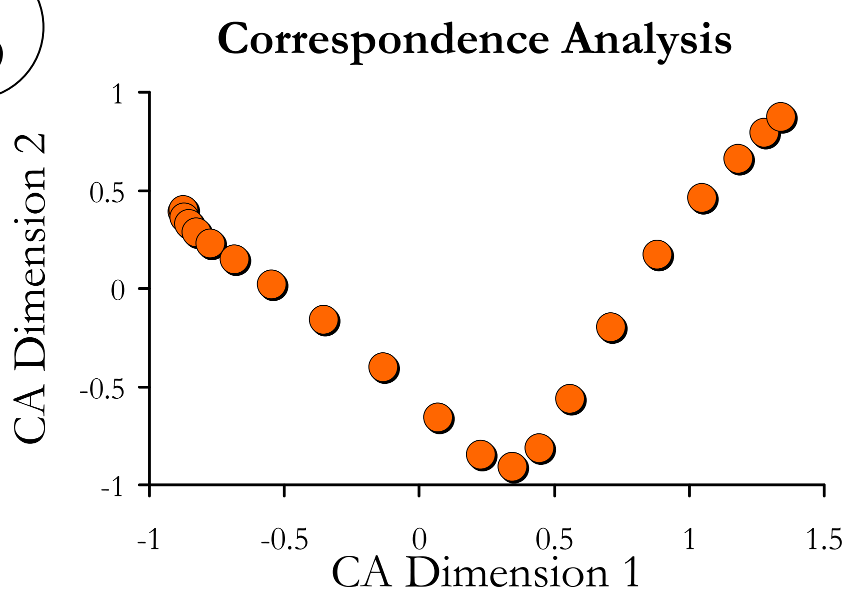

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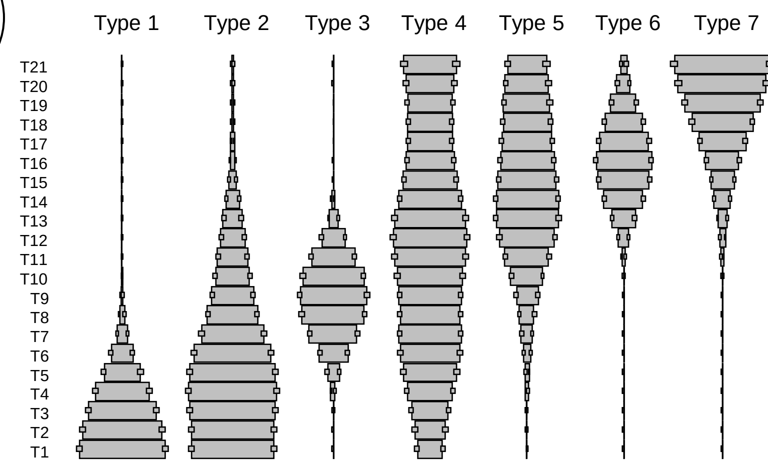
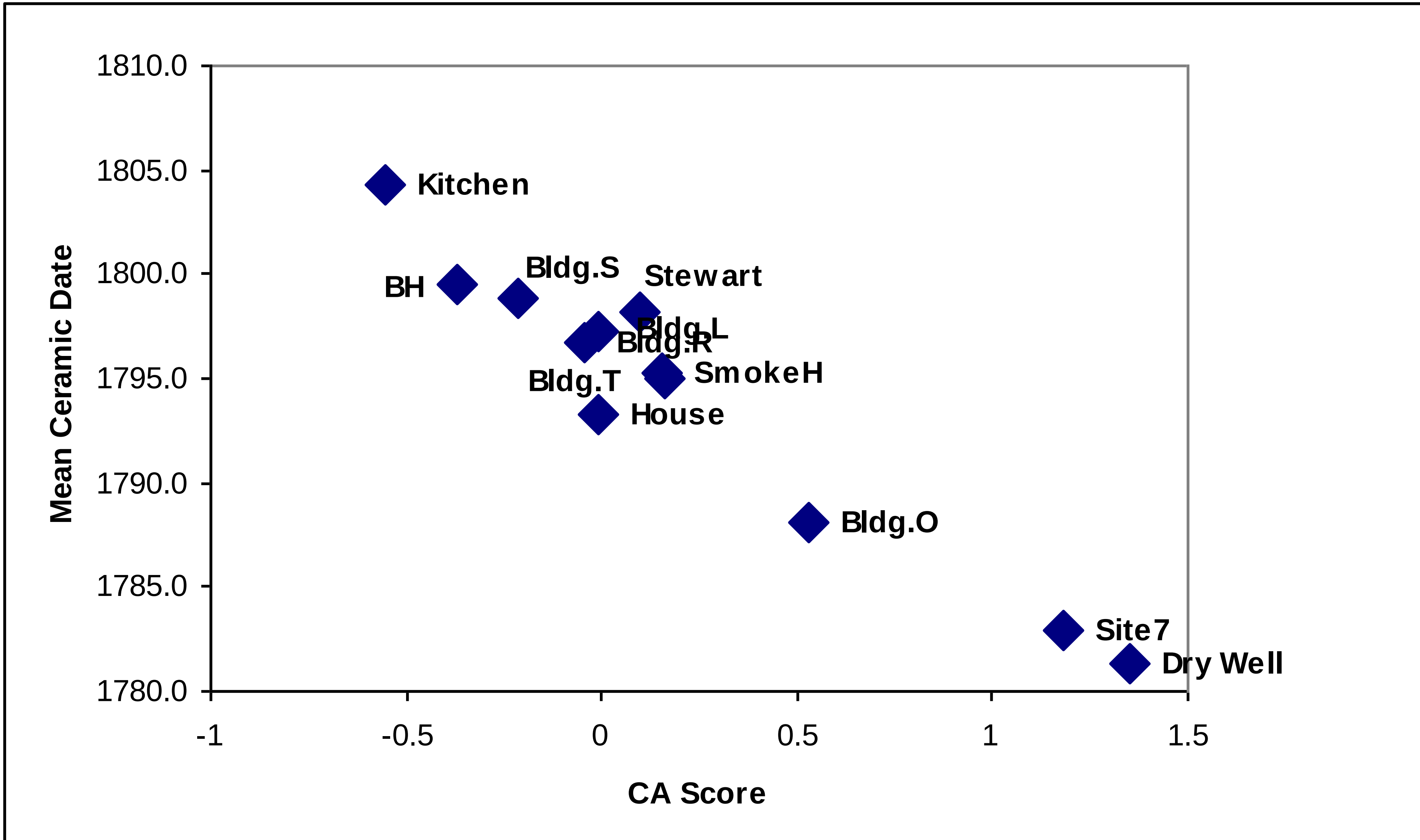


MCD vs. CA



Mean Ceramic Date
1810.0
1805.0
1800.0
1795.0
1790.0
1785.0
1780.0
-1
-0.5
0
0.5
1
1.5
CA Score
Kitchen
BH
Bldg.S
Stewart
Bldg.L
Bldg.R
Bldg.T
SmokeH
House
Bldg.O
Site7
Dry Well

Frequency Seriation Methods

Comparison of Model Assumptions

1. Frequency Seriation

- types display battleship-shaped curves on a single gradient (time)
- temporal overlap of types
- same “local area” and “cultural tradition”
- similar time averaging across assemblages
- little sampling error

2. Correspondence Analysis

- all of the above. Plus....
- types display Gaussian curves on one or more gradients
- uniformly distributed type maxima, type variances, assemblages.

3. Mean Ceramic Dating

- all of the above. Plus....
- types display Gaussian curves on a single gradient
- type variances similar
- dates of type maxima are known

4. Pipe-stem Dating

- bore diameter class maxima are evenly spaced in time.