B. The number of components

Consequences of this notion

- The number of visual variables necessary for the representation is at least equal to the number of components in the information.
- With three components, the information can be perceived as a single image. Beyond that, the perception of several successive images is often necessary.
- There are at least as many types of possible questions as there are components.
- The number of components is the best basis for a classification of graphic constructions.

Take the following information:

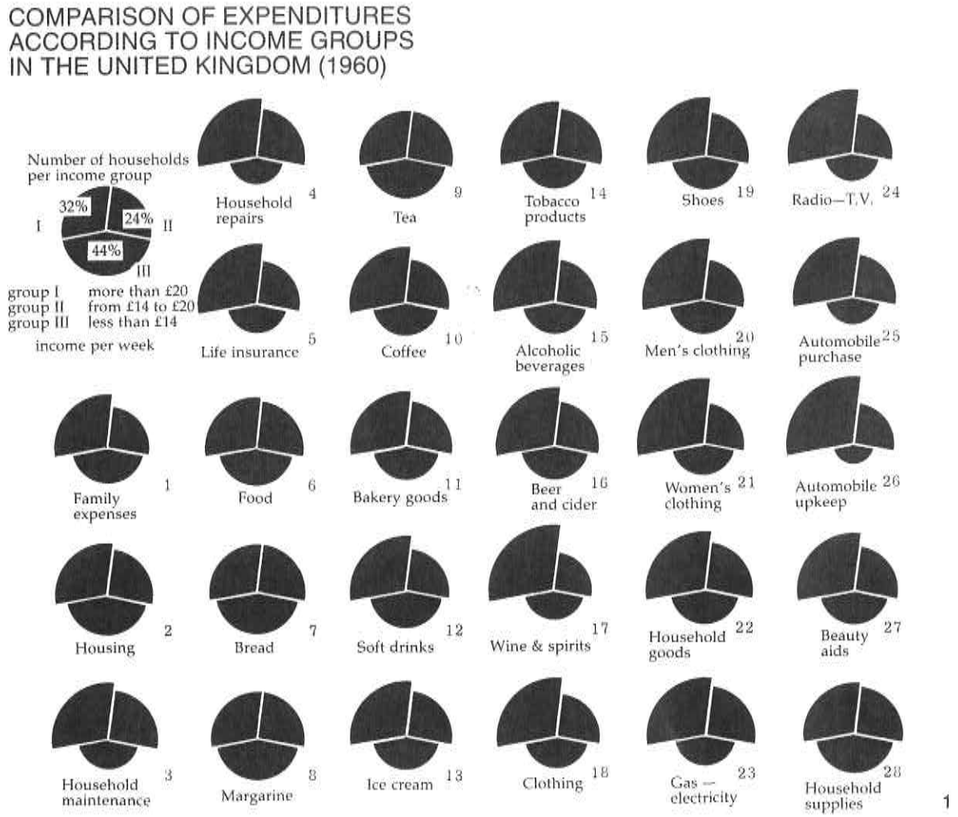
INVARIANT — *–expenditures by the British population per item*

COMPONENTS — *–twenty-eight different items of expenditure*
–Q per 100 expenditures per item according to
–three income groups (upper, middle, lower)

Because the information involves only three components, it is possible to replace figure 1, necessitating the mental addition of numerous images, by figure 2, which presents a memorizable image.

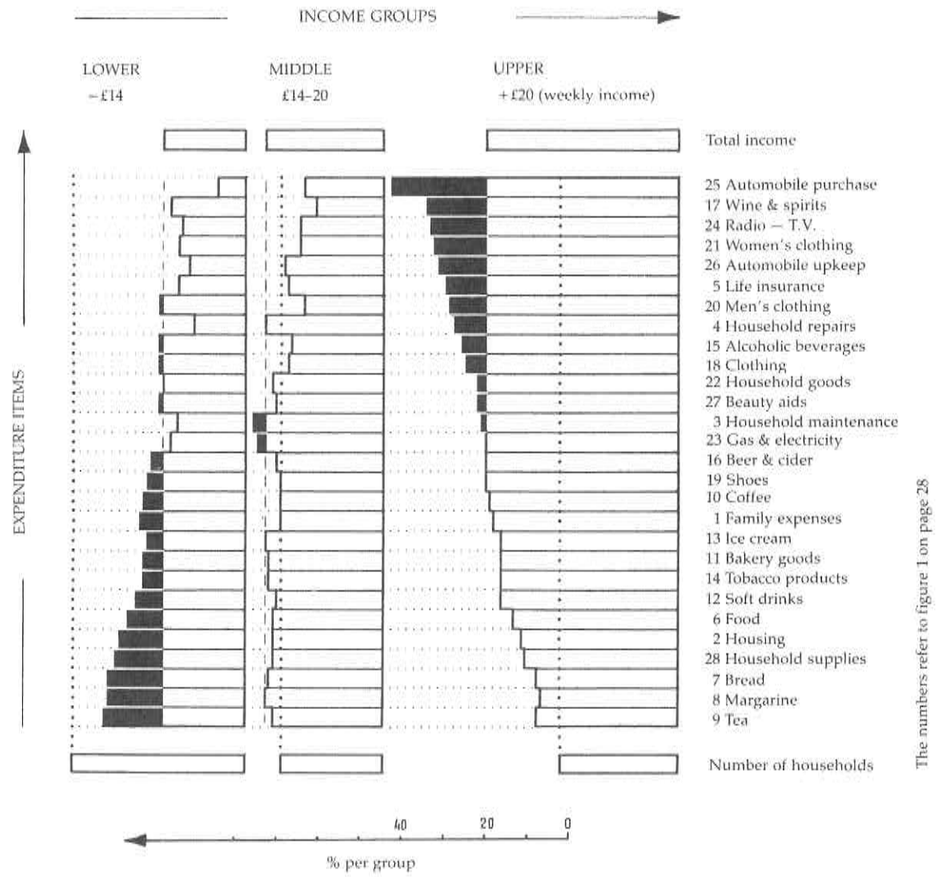
It is a feeling of uniformity, of nonvariation, which results from figure 1, yet the distribution of expenditures could hardly be similar for all three income groups.

In figure 2 the reader is struck and guided by the visible differences (underscored, incidentally, by the use of black) and is able to concentrate on them. The reader can rapidly perceive the logical order of the image: From left to right are the groups, from top to bottom are the items, whose order constitutes the very purpose of the information. The reader can pose questions about the characteristics of a group or an item, or about the order of these items, and feel confident of obtaining an answer.



1

from Harry HENRY, Thomson Organisation Ltd.
Sources: Central Statistical Office, London 1961



The numbers refer to figure 1 on page 28

2

TRAFFIC ACCIDENT VICTIMS, in France, in 1958

VEHICLE (or pedestrian)
QUANTITIES

V \ Q	Pedestrians	Bicycles	Motorcycles	Four-wheeled vehicles
	28 957	17 247	74 887	63 071

VEHICLE
SEX
QUANTITIES

V	Pedestrians		Bicycles		Motorcycles		Four-wheeled vehicles	
S \ Q	M	F	M	F	M	F	M	F
	16 702	12 249	13 009	4 238	61 609	13 278	39 732	23 339

VEHICLE
SEX
CONSEQUENCES (dead, injured)
QUANTITIES

V	Pedestrians		Bicycles		Motorcycles		Four-wheeled vehicles	
S	M	F	M	F	M	F	M	F
C \ Q								
d	1 232	570	701	126	2 664	322	1 817	694
i	15 470	11 679	12 308	4 112	58 945	12 956	37 915	22 645

VEHICLE
SEX
CONSEQUENCES
AGE
QUANTITIES

V	Pedestrians		Bicycles		Motorcycles		Four-wheeled vehicles	
S	M	F	M	F	M	F	M	F
C								
A \ Q								
50 d	704	378	396	56	742	78	513	253
50 i	5 206	5 449	3 863	1 030	8 597	1 387	7 423	5 552
30 d	223	49	146	24	889	98	720	199
30 i	3 178	1 814	3 024	1 118	18 909	3 664	15 086	7 712
20 d	78	24	55	10	660	82	353	107
20 i	1 521	864	1 565	609	18 558	4 010	9 084	4 361
10 d	70	28	76	31	362	54	150	61
10 i	1 827	1 495	3 407	1 218	12 311	3 587	3 543	2 593
d	150	89	26	5	6	6	70	65
i	3 341	1 967	378	126	181	131	1 593	1 362

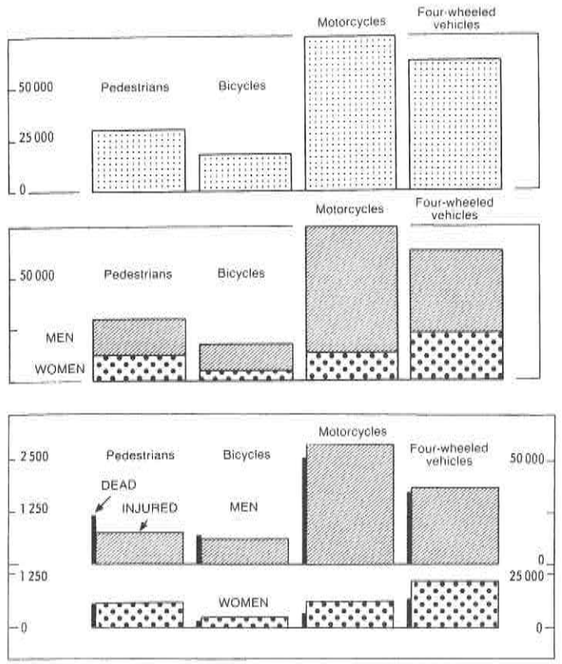
Source: Ministère des Travaux Publics

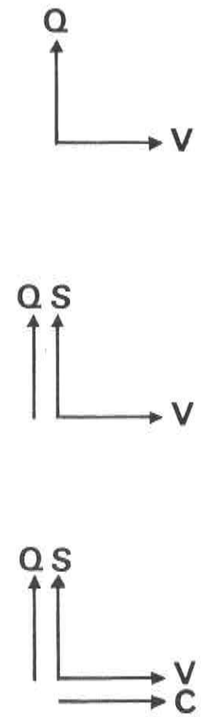
1

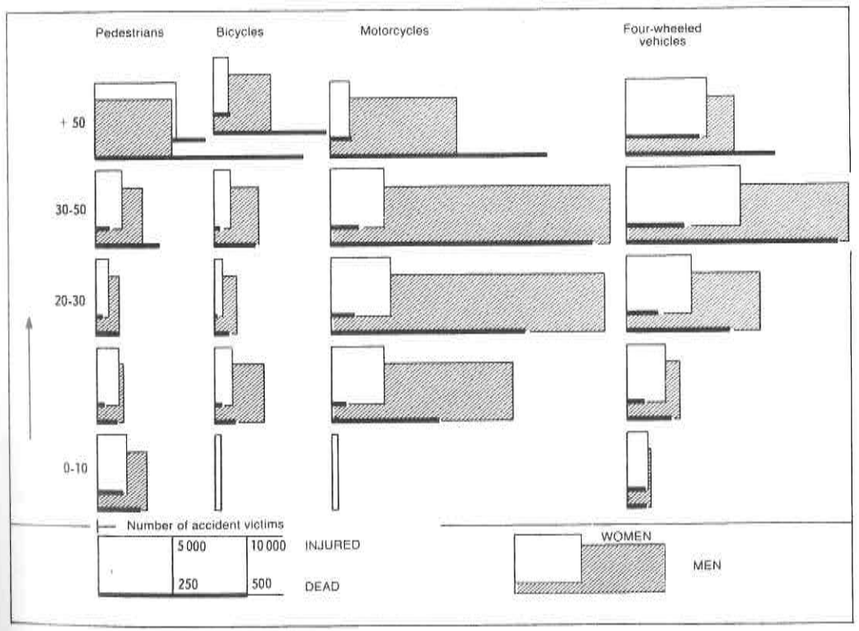
Information can have 2, 3, . . . *n*, components, and *n* can be quite large. It is sufficient that one of the components or the invariant be common to all the data.

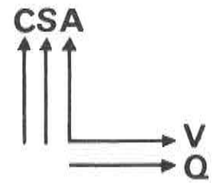
Consider the following example:
Analysis of highway accidents in France.
INVARIANT *–an accident victim*

This example can involve numerous components. As we see in figure 1 each additional component will generate new information. Furthermore, each additional component will also require a new visual variable leading to a different construction, as illustrated in figure 2 on the opposite page.









2

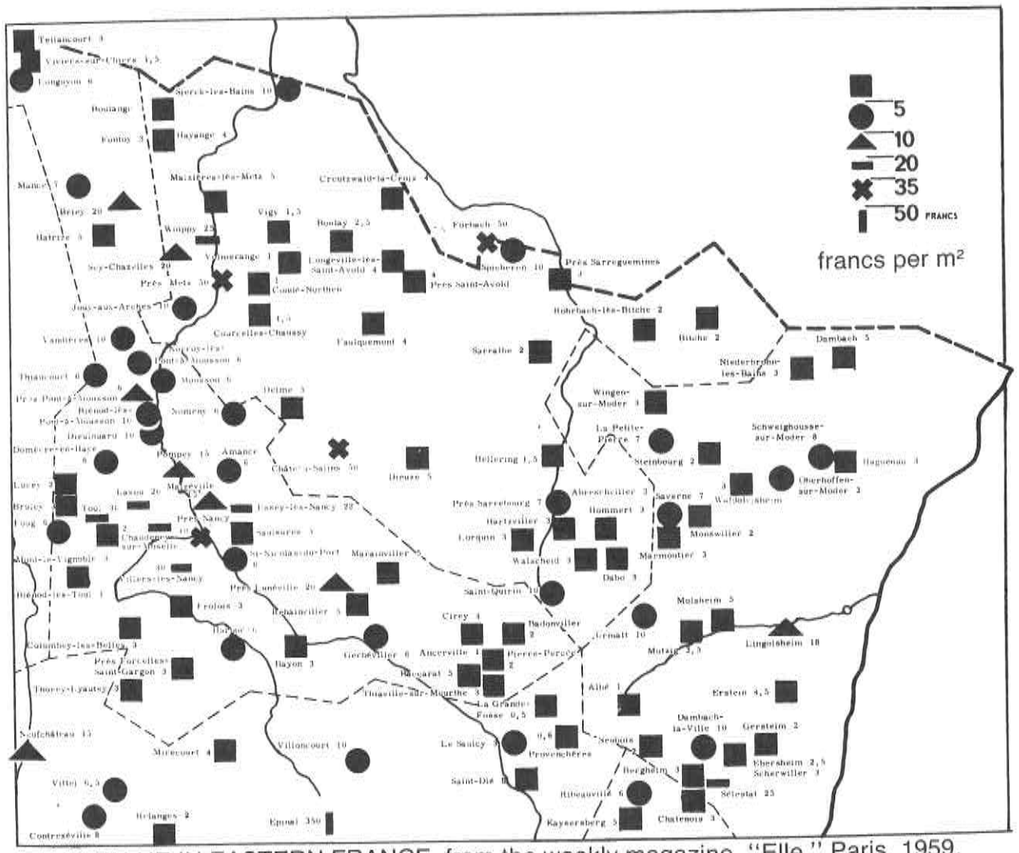
D. The level of organization of the components

The components of the information do not all involve the same intellectual approach. For purposes of information processing and/or display, the researcher will often attempt to order qualitative (nominal) categories such as trades, to compare ordered categories such as heat sensitivities, and to group neighboring quantitative values such as population densities.

A component can thus be characterized as *qualitative*, *ordered*, or *quantitative*; these are the three levels of organization. The visual variables which represent each component must permit parallel perceptual approaches. But, just like the components, the visual variables each have their own level of organization. An order will not be perceptible if the variable is not ordered; a ratio will not be perceptible if the variable is not quantitative. The notion of level of organization is thus of fundamental importance.

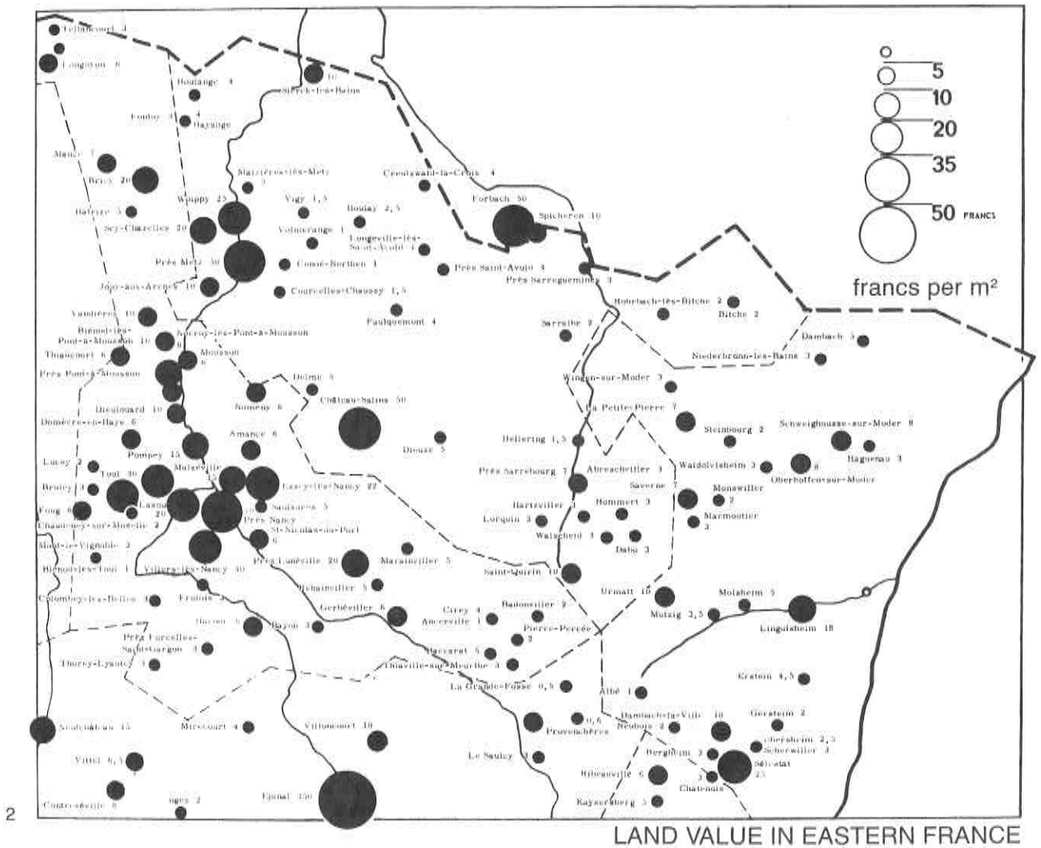
Consequences of this notion

- The ordering of qualitative data, the comparison of ordered components, the groupings resulting from a quantitative component are the basis for the graphic processing of information.
- The visual variables must have a level of organization at least equal to that of the components which they represent.
- The three levels of organization lead to the first subclassification of graphic constructions.



1 LAND VALUE IN EASTERN FRANCE, from the weekly magazine, "Elle." Paris, 1959.

It is because the level of the visual variable utilized does not correspond to the level of the component represented by it that the map in figure 1 is inefficient and necessitates the burdensome reading of several successive images. When the levels correspond, as in figure 2, the map is visually retainable. It necessitates only one immediately perceived image.



2 LAND VALUE IN EASTERN FRANCE

THE QUALITATIVE LEVEL (OR NOMINAL LEVEL)

This notion includes all the innumerable concepts of simple differentiation: professions, products, languages, races, religions, leisure activities, diseases, colors, forms, social, ethnic, cultural or political traits . . .

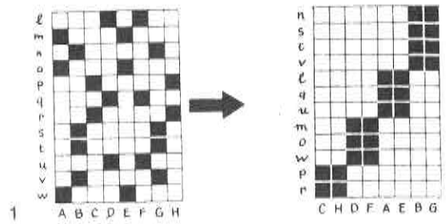
A component is qualitative when its categories are not ordered in a universal manner. As a result, they can be reordered arbitrarily, for purposes of information processing.

Qualitative categories are reorderable

In maritime commerce, for example, the categories coal, oil, wheat, wool, cotton, wine, wood, . . . of the component "merchandise" can be ordered in different ways, according to weight, total value, price per kilogram, volume, revenue production, fragility. . . .

Geographic groupings are also reorderable. Departments are commonly classed by alphabetic order, countries by their population, their production, their standard of living, their birth rate. . . .

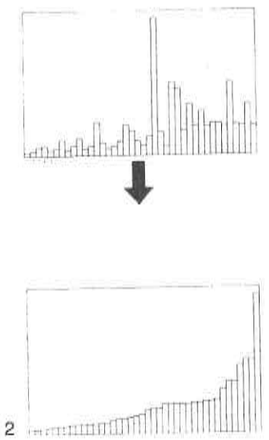
The reciprocal ordering of two qualitative components (figure 1) or of a qualitative component in relation to an ordered component (figure 2) simplifies the images without diminishing the number of observed correspondences; indeed these operations of "permuting" and classing are the basis for graphic information-processing.



1

Qualitative categories are equidistant

As with ordered categories (discussed later), qualitative categories are, by definition, of equal importance, that is, "equidistant." Their graphic representation must not disturb this quality by highlighting a particular category or creating a priori groups of categories.


2

Two perceptual approaches

Faced with any qualitative concept, the observer can adopt two perceptual approaches:

This is different from that—a beech tree is different from an oak.

This is similar to that—beeches and oaks are similar—they are trees.

A *selective approach (difference)* is engendered by questions of an elementary or intermediate reading level. Where is a given category—the beech trees? When these questions are pertinent, it is important that the component be represented by a selective variable.

An *associative approach (similarity)* is engendered by questions of an intermediate or overall reading level. Where is a given component—the forest—all categories of trees combined? In order to reply to this question, the variable must permit equalizing and grouping all the categories during perception; it must be associative.

THE ORDERED LEVEL (ORDERING AND REORDERING)

This level groups all the concepts which are capable of ordering categories in a universally acknowledged manner. Each person will agree in the same way that this is more than that and less than the other.

Ordered concepts are always defined, more or less directly, in relation to:

- a temporal order: age, generation, matrimonial status, geologic era
- an order of sensory discrimination: heat, vision (black–gray–white, large–medium–small, here–near–far), weight (heavy–medium–light), health
- an order of intellectual or moral discrimination (good–mediocre–bad)
- certain social structures, such as military or administrative hierarchies.

A component is ordered, and only ordered:

- **when its categories are ordered in a single and universal manner**
- **when its categories are defined as equidistant.**

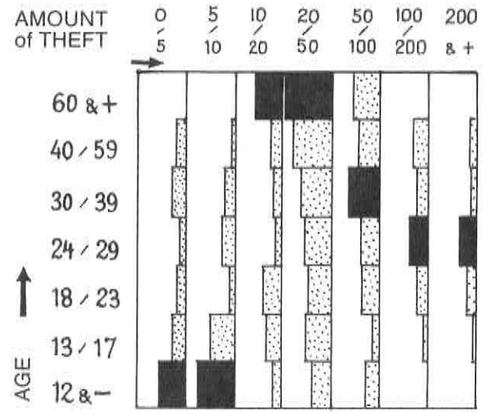
Ordered categories cannot be reordered

More precisely we can say that the reclassification of ordered categories is generally a source of confusion in the process of communication.

Consider the following example:

Propensity to theft according to age and amount of theft (based on V. V. Stanciu, Theft in Department Stores, unpublished study).

INVARIANT –*theft in department stores*
COMPONENTS –*age groups*
–*quantities (per 100 persons per age group) according to*
–*classes of amount of theft*



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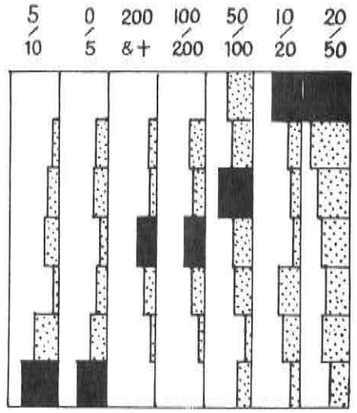


4

THEFT IN DEPARTMENT STORES
Distribution of delinquents according to age and amount of theft

The components "age" and "amount of theft" are ordered, producing figure 3: In black is the highest percentage for each column, that is, the age group with the strongest observed tendency.

It can be of interest to reorder the component "amount of theft" for the purposes of constructing a linear relationship (figure 4), which permits one to reflect on theft psychology. Interpretation is more delicate, however, because reading from left to right no longer has an ordered meaning.

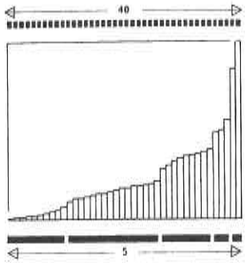
These examples demonstrate that the amount of theft is not ordered in a direct way by age, nor age by amount of theft.

Ordered categories are defined as equidistant

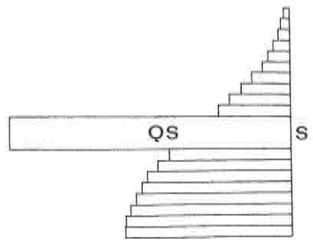
This characteristic distinguishes an ordered component from a quantitative component. The series: bachelor, husband, widower, deceased, constitutes a universal order. But there is no reason, a priori, to bring together any two categories or to form groups. These categories are ordered and at equal distances from each other.

The same is true for the component "amount of theft," even though its categories are defined by *numbers*. These are *ordinal numbers* which merely serve to rank the categories.

In any graphic transcription involving an ordered component, particularly when using "retinal" visual variables, the designer must try to preserve this equidistance. A priori visual groups must be avoided, since the very purpose of graphic processing is to discover, a posteriori, the groupings which result from the information.



1



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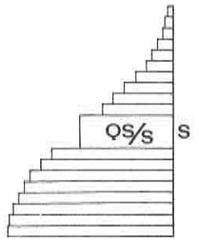


3

THE QUANTITATIVE LEVEL (INTERVAL-RATIO LEVEL)

This level is attained when there are countable units, leading us to say: this is double, half, four times that. . . .

A series of numbers is quantitative when its object is to specify the variation in distance among the categories.

With a quantitative series of numbers, Q, it is possible to represent a variation in the length of columns, as in figure 1, and from this to derive groups, characterized by slight differences in length (slight "distances").

Relations among quantities and enumeration units

Before representing given quantities, any graphic must first depict the units (geographical areas, time periods, age groups, etc.) within which these quantities are being enumerated. A population map by commune is, first of all, a map of communes.

When the enumeration units are unequal:

- the representation of these units on the plane can result in figures which are equal (points on a diagram) or unequal (a map of communes);
- the representation of the quantities can be independent of the inequality of these figures (a single point per area) or dependent on it (color over the entire area).

But the quantities themselves can be independent of the inequality of the enumeration units (death rate in a commune) or dependent on it (total population). Therefore, graphic representation necessarily leads to an initial analysis of any quantitative series in terms of these relations.

Quantities dependent on the enumeration units (or QS)

In comparing communes, the geographer must calculate population density in order to take the unequal areas of the communes into account. This calculation is necessary because the quantities of population *are not independent of the unequal areas* (S)* of the communes. The same is true for the historian who uses quantities of immigrants enumerated over unequal periods (S) of time or for the demographer who uses quantities of persons counted within unequal age groups (S). These quantities are not independent of the dimension (S) of the enumeration units.

*S will be used frequently to signify area, since it comes from the French equivalent *surface* (translator's note).

Quantities of the form QS are:

absolute quantities (Q) counted according to variable units (S), whether these quantities are expressed:

by the observed numbers:

Q of tons of milk per department (S), Q of persons per period (S) . . .

in hundredths (or in thousandths of the total):†

Q of milk per department (S), Q of persons per age-group, expressed in hundredths (or in thousandths) of the total of the series, that is, QS × 100/total of the series.

Test: For a hundred what? For a total of the series equal to a hundred;‡

by an index:†

Q of milk consumed per period (S), per 100 liters consumed in 1950 (Qi), Q of milk produced per department (S), per 100 liters produced in the department of Calvados (Qi), that is, QS × 100/Qi.

Test: For a hundred what? For a hundred liters produced in Calvados;‡

by a ratio based on a variable independent of S:

Q is monthly average amount of milk produced per department (S), or Q is communal average of expenditures per period (S), that is, QS total/number of units (months, communes). When S is represented by lines or by areas, the graphic transcription of QS can lead to serious errors (page 45). It is generally necessary to transform the data by making the calculation QS/S, as illustrated in figures 2 and 3.

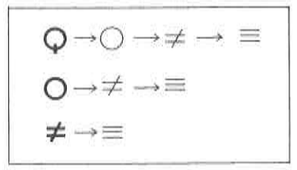
Quantities independent of the enumeration units (or Q)

The geographer looking for quantities of population independent of the area of a commune must calculate densities: Q of population/area, that is, QS/S = Q.

The demographer will reduce a class variation in the same manner: Q of persons/length (in years) of the class, that is, QS/S = Q. But quantities Q are not all of this nature.

†Hundredths and indices merely involve a simple change of numerical scale, useful in verbal communication to the degree that all the numbers become intelligible when it is understood what one hundred or one thousand represents. Graphically, absolute Q, hundredths, or indices produce the same image of a series.

‡The test, for a hundred what?, is indispensable. It permits the elimination of false percentages and the comprehension of what is in question. It obliges one to furnish the elements of an answer and it reveals, all too frequently, a series for which an answer is impossible, so that clarification or elimination of the series is required.



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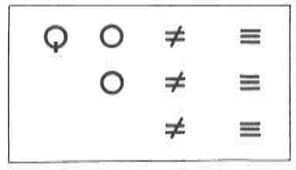

5

Quantities of the form Q are:

samples, altitude, temperature, commodity prices, number of workers per factory, etc. These are measurements or real values sampled at a point which is by definition without length or area. They thereby characterize an invariable enumeration unit;

reductions to a unitary class, densities, "absolute" frequencies, such as the examples cited earlier, which result from the operation QS/S = Q;

simple ratios, in which the variable unit (S) relates the two terms of the ratio:

Q of wheat produced per commune (S)/Q of hectares sowed per commune (S),

Q of emigrants per period (S)/Q of boats per period (S), that is, QaS/QbS = Qa/Qb = Q′;

"percentages" and "rates" which multiply the simple ratios by a hundred (or a thousand):

Q of deaths per commune (S) × 1000/Q of persons per commune (S),

Q of working persons per age group (S) × 100/Q of persons per age group (S), that is, QaS × 100/QbS = Qa/Qb × 100 = Q′ per hundred.

Test: For a hundred what? For a total of a hundred persons per commune.‡

The graphic transcription of absolute quantities (Q) is simpler. However, one must know how to avoid a confusion with graphic solutions suitable only to QS (figure 16, page 45).

INCLUSIVENESS OF THE LEVELS OF ORGANIZATION

Graphic conventions

In order to designate a component and, at the same time, specify its level of organization, the following signs will be used:

Q—a quantitative series measuring variations in distance among ordered categories.

O—a component whose categories are equidistant and inscribed in a single, universally acknowledged order.

≠—a qualitative component whose categories are defined and equidistant.

≡—a qualitative component whose differential characteristics can be disregarded (i.e., which can be approached "all categories combined").

Inclusiveness of perceptual approaches

The level of organization determines the perceptual approaches that can be adopted toward a component. These approaches are ordered and inclusive. In effect, *for a quantitative component*, it is possible to adopt:

a quantitative perceptual approach and ask the question: What is the ratio between the two lengths, between the two populations, between the two areas. . . ?

an ordered perceptual approach and ask the questions: In what order are the lengths given? Does the order of the departmental population quantities correspond to the alphabetic order of the departments . . . ?

a selective perceptual approach and ask the question: Where are all the cities of 15 000 inhabitants?

an associative perceptual approach and ask the questions: What is the distribution of the "cities," disregarding any differentiation among them? Where is the forest, disregarding any differentiation of age, size, or kind of trees?

Thus:

- **All quantitative series can be considered as merely ordered.**
- **All the categories of an ordered series can be considered as merely differentiated.**
- **All the categories of a qualitative series can be considered as similar.**

But:

- **A series which is only qualitative is not ordered (although we can reorder it arbitrarily, page 36).**
- **A series which is only ordered is not quantitative (although it may be defined by ordinal numbers, page 37).**

The system of inclusion resulting from these statements is expressed in figure 4, a more readable version of which is given in figure 5. This enables us to identify the perceptual approaches which each component can generate, to choose a visual representation of at least an equal level, and to classify the visual variables among themselves.