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Visualizing Excavations Records by Means of Information Design

Creating Knowledge Visualizations from Cultural Heritage Data

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Abstract:

The original find-contexts of artefacts, and architectural features retrieved by an archaeological excavation, are destroyed and virtually torn out of their specific spatial cohesion. For this reason, all excavated elements are thoroughly documented in the excavation records by means of photography, drawings and text-based descriptions. This heterogeneous data, however, is only accessible consecutively, is mostly text-based, and rarely related to each other. As such, excavation records are primarily to be seen as an archive. To be able to present and communicate the results of an archaeological excavation to both the scientific community and the general public, the data needs to be processed accordingly.

The following work demonstrates how cultural heritage can be transformed using alternative methods of information design. Graphical systems translate the data of the excavation records into visualizations. To bring structure to the disparate data, the records are sorted according to several visualization models. Translating the excavation documentation into a graphical language enables us to structure the data by theme, to interlink it and to create an overview. Such visualization techniques serve to analyze the stored data, help to create new perspectives on the material, and thereby help us towards an improved understanding of the excavation. The visualizations therefore provide a basis for the communication of scientific results and can be used in publications, educational books and museums, in order to depict cultural heritage in an easily accessible as well as a more intuitive, explicit manner.

Keywords: Cultural Heritage Visualization; Information Design; Visual Taxonomy; Archaeological Communication

Introduction of the author:

Fabienne Kilchör is a Ph.D. student at the University of Bern in Switzerland, specializing in the visualization of cultural heritage data. She works on interdisciplinary research projects of the Swiss National Science Foundation in the field of data visualization, based at the University of Bern in conjunction with the Bern University of the Arts. Besides academic research, Fabienne is also the Creative Director of Emphase Inc., an agency she has co-founded for visual communication and information design. Furthermore, she teaches information design at the University of Art and Design in Geneva.

I. Introduction

This paper is divided into five parts. In the first part, a brief introduction on currently ongoing archaeological practices is given in which the research problem is presented. The second part uses specific material from the documentation of an archaeological collection to show the characteristics of cultural heritage data. Orienting itself on the target audience of information graphics, the third section is intended to demonstrate how and where knowledge visualizations can be used. The fourth part presents visualization methods and approaches to solving the problem at hand. The fifth part summarizes best practices by offering examples from state-of-the-art visualizations and ongoing work at an excavation site. The present paper is a contribution to a visual hermeneutics of artefacts of cultural heritage that offers new approaches to historical data by means of information design.

2. Collecting, documenting, visualizing

Within archaeology, excavations continue to play an important role in acquiring data. Minor finds and ceramics are wrested from their original context when they are excavated. This means that chronological and chorological relationships are lost. Architectonic building finds are carried away layer by layer and thereby irretrievably destroyed. In order to capture the data and to secure it on a long-term basis, it is archived in a database. The inhomogeneous collection grows with every new campaign and a considerable wealth of barely manageable data is amassed. Data comparison is made more difficult by the broad, flat organizational structure of the database. Database masks for finds and findings do not allow one to view several datasets at once, which means that relationships between them are not visible and can only be ascertained by means of a select list in a table. Text-based entries are used to reconstruct the chronological sequence of layers, for which predefined selection fields are employed. For this, finds and findings must be transferred into a text-based documentation in which the cultural artefacts – which have a very strong visual aspect – are rendered considerably abstract. There is a great loss of information in the process. The variety and heterogeneity of the largely text-based datasets restrict the possibility of having an overview or a comparison of the collection. By viewing the data in an isolated fashion, it is made more difficult to contextualize and correlate data with each other.

This assessment makes evident why excavation documentation is primarily a storage medium. In order for the digitized collection to serve not just as an archive, alternative methods should be developed to utilize the documentation of a collection. For this, data has to be prepared so that one might work with it in a subsequent step, that one might investigate it and employ it to communicate new knowledge. Our cultural heritage can be processed, translated and communicated using methods of information design. The focus here lies on the following three

aspects: a graphical depiction of the cultural artefacts allows complex finds and findings to be compared and regularities identified. The representation of knowledge is concerned with data transport and the problem of reducing complexity by means of abstraction. The information loss as a result of transforming it into text should be countered by means of illustrations. The data network allows the correlation of data that in turn means the find context and functional connections can be recorded.

Documentation strategies generally lag behind general developments, which are tending away from viewing individual artefacts and instead aim at investigating cultural relationships. By describing their shifting significance and by allowing a multiplicity of understandings of the finds and findings in their respective contexts, we achieve the "necessary expansion of our means of viewing, in order to describe objects in their respective context and thereby investigate life relationships" (Schneider 2006, 18). Because "for a long time, archaeology has seen its primary task less in collecting and archiving than in the reconstruction of historical relationships" (Schneider 2006, 8). Achieving a better understanding of past cultures is thus the core focus of data visualization.

3. The characteristics of cultural heritage artefacts

3.1 Heterogeneity

When quantifying cultural artefacts, we can differentiate between two types of data. There are the objects themselves – Sula refers to the "content of items themselves" (Sula 2013, 26) – and the digitized, scanned data that has been entered into the database, which is described as "metadata". An inventory of finds, ceramics and findings is very different in nature [fig. 1]. Its documentation forms can be summarized in a brief textual description and a visual documentation in which drawings of finds, field sketches, plans, sectional drawings, photographs of finds and field photographs, satellite images, laser scans and tachometric observations form an essential part of the documentation (Flügel 2001).

3.2 Indeterminacy

Cultural artefacts must be dated and described precisely in order for reliable analyses and queries to be carried out in the database. The custom of using a timeline compels the scholar to assign an exact date to objects, whereas in fact objects have often been made during a broader time period. If grey areas, doubts and even information gaps in determining dates of origin or in describing cultural artefacts are not registered in a differentiated manner, this can have a major influence on their interpretation and on the conclusions drawn from them. Imprecisions must be made evident in a graded visualization, and suppositions must be taken into account.

3.3 Quantity and quality

Characteristics, entities, groups and collections feature in the hierarchy levels of the data to be visualized. This graded level of detail does not completely exclude anonymization through the transformation of the data, but it yields a proximity to the object that is necessary when dealing with artefacts of cultural history.

The function groups can be mapped by means of qualitative methods. Time and space are two orientation systems in which data can be located. Object-specific details such as formal typological characteristics are nominally scaled and are measured using the categories described. Although the characteristics are operationalized, they are not ordered unambiguously. Quantitative methods use abstraction and thus forego individual, qualitative object information. For this reason, existing statistical means do not allow context-specific and visual information to be differentiated and recorded clearly enough, all at the same time. Instead, the information has to be broken down in multitrack translation processes. The methods of information design are thus to be used to visualize document-centric information (Pitti 2004) and quantitative data in combination with each other.

4. Knowledge visualization

Before the Iconic Turn, specialist scientific journals were largely non-pictorial, and this was even the case with popular science magazines published for a general readership (Janser 2005, 5). The utilization of knowledge visualizations (Boehm 2001/2010) in order to provide the reader with a means of orientation and to illustrate complex topics has not ousted the written word, but relativized it (Janser 2005, 5). On the level of communication at symposia, in publications, teaching books or on museum display boards, an emphasis is placed on attaining the highest possible degree of accessibility. But in the humanities and in the history of the arts in particular, where non-verbal pictorial communication is not yet a common practice, the explanatory image still has to prove itself. When working with cultural history data, pictorial references play a central role. Images are constructs that are able to make the hidden visible (Boehm 2001). As “utilitarian” images they are instruments in the service of communication and are intended to stimulate us to think.

If we define information graphics as deictic, “explanatory” images, then they should be used in analysis, just as in communication in the interdisciplinary discourse and in popular science. Visualization has three goals:

1. In an explorative investigation (Schumann/Müller 2000, 5), visualization takes the raw data as its starting point. The images aid the undirected search for information and structures, help in the development of hypotheses and, as Plaisant formulates it, help us to answer questions that we have not even asked before (Plaisant 2004).
2. In confirmative analysis, visualization also takes the data as its starting point, but uses this in order to verify facts. Visualization here helps scientists in their line of reasoning.

Visualization processes support the evaluation of the data, allowing new perspectives and serve to improve our understanding of the documentation (Chen 2003, 35). The knowledge visualizations offer researchers new findings.

3. The application of visualization in communication should make scientific findings accessible to researchers and should explain complex facts to a broader public.

Contrary to Boehm, who barely assigns any importance to aesthetic criteria, we can show that information design can contribute a feeling for form, visual features and an elaborated design that can be prerequisites for creating new knowledge (Noble/Bestley 2005).

5. Information design as a method of visualization

Information design assists human perception by helping us to comprehend large-scale information. Visualizations allow much information to be made available in a small space, and allow us to grasp the data structure at a glance. Furthermore, information can be grasped quicker thanks to the compact overview offered. Knowledge visualizations can lessen the degree of transformation necessary for finds and findings and can heighten the degree of emotional impact. Visualizing cultural data makes it easier to extract information and allows us to gain new insights (McCandless 2009, Tufte 2001). Edward Tufte impressively demonstrates the added value of information design using Charles Minard's 1869 flow map of Napoleon's March [fig. 2], which as he says "may well be the best statistical graphic ever drawn" (Tufte 2001, 40). This graphic displays several variables in a single two-dimensional image. The Sankey diagram – a graphic depiction of quantity flows – shows the number of men in Napoleon's 1812 Russian campaign army, their movements as well as the temperature they encountered on their return path.
Tufte's "Fundamental principles of analytical design" (Tufte 2006, 122ff.) can be verified clearly using this graphic.
When applied to the visualization of cultural artefacts, these principles apply as follows:

1. The data must be prepared in such a manner that comparison is possible. This is to be combined with a categorization and harmonization of the data. The visual variables [fig. 3] of Jacques Bertin (Bertin 1967, 51) may be drawn upon to differentiate the data sets. This cartographer, whose book *Sémiologie graphique* of 1967 was the first standard work on graphic theory and visualization, developed the model of graphic variables with which he shows that a conventional sign can be constructed comprising orientation, size, shape, colour, texture, value and position.
2. In order to generate informational added value by means of visualization, information has to be correlated. Causal relationships, mechanisms or systematic structures are only as meaningful as the question one asks of the material.
3. As in the geographical map of Charles Minard, visualization becomes more condensed, the more variables are compared with each other. Unexpected causal relationships can

thereby be recognized. This principle serves an exploratory investigation, and Tufte argues in favour of an analysis with more than one or two attributes.

4. In the case of highly layered cultural data, complexity must be reduced. Graphics can be combined with images, text and numbers, which is useful for guiding the reader. Storytelling – by using visual metaphors – is important in data visualization inasmuch as the recipient of this visual, graphic language is often not accustomed to it. Pictograms and a uniform notation system help us to design the graphic so that it is more intuitive.
5. Even after the Visual Turn, and increasingly thanks to the development of digital media, the image has to assert itself anew. With clear documentation, sources, precise information and an aesthetic that corresponds to the topic, the graphic can gain in plausibility and be used as a line of reasoning.
6. Tufte's sixth principle places the data before the design. "Content counts most of all" (Tufte 2006, 124) refers to the necessity of visualization being generated by the data; it should not be design-driven. The visual formulation supports the content, according to the fundamental principle of "form follows function". Information design is situated between form and function. Every graphic element has to be applied in a goal-oriented manner. In this paradigm, the aesthetic must not be underestimated.

Visualization can bring about a broad degree of abstraction. The approach involved begins with the transformation of digitized data, translating it into information by means of visualization methods. Information designers regard the selection, the structuring and the presentation of the data as part of their task. Interdisciplinary collaboration with different specialists is indispensable. Abilities are thus necessary in the fields of graphic design, typography, programming and perception psychology or usability (McLoad 2003). Furthermore, an intensive exchange with archaeologists aids an improved understanding of the data and the indispensable clarification of the question to be posed to the material. In an iterative design process, visualization concepts are devised, realized graphically, discussed and revised.

For an efficient transfer of the data into a visualization, the following four relevant questions must be asked: For whom is the visualization intended? What is the goal of the visualization? What data is being visualized? What methods should be employed for the visualization? The framework [fig. 4] is the determining factor for the development of the knowledge visualizations, taking Burkhard's reference system (Burkhard 2005, 245) and Klanten's representation typology (Klanten *et al*., 2008) as its starting points.

6. Visualization concepts

The process of data visualization is divided into two developmental steps. First the information structure is prepared and the data is harmonized and translated. This translation process is aptly described by Chafe as “information packaging” (Chafe 1976, 28), and in this design phase the framework of the graphic is constructed. In a second step, the framework and the notations are brought together and transferred into selected graphic representation models.

6.1 Information structure [fig. 5]

The architecture of the visualization is devised in an intensive design phase. Sketches serve as a basis for discussions with the archaeologists and the end users. By engaging with specialists, it becomes clear what hierarchy level should be assigned to what information, and what questions have to be asked of the material.

6.1.1 Notation system [fig. 6]

After an analysis of the data, it is harmonized and prepared for the visualization. One method of harmonizing heterogeneous data is to design a visual notation system (Crow 2005). Pictograms can be employed as attribute symbols. A simplified graphic depiction offers a direct, unambiguous sign language. By introducing a notation system, very different data can be united.

6.1.2 Data architecture [fig. 7]

After clarifying the data types, the architecture of the visualization is devised. Usually, the data in the database is subject to a broad, flat structure with few hierarchical levels, meaning a process of gradation must first be undertaken. The structure is achieved by grouping, contrasting, comparing and lining up the data. Here, at the latest, the usefulness of a classification system becomes clear. In many common archival programs and databases, drawings and photographs are often only linked through thumbnails; here the image serves merely as an accompanying record to the text on this level of the hierarchy. Visualization allows this hierarchy to be turned around. Hierarchies can be differentiated visually by means of colour coding, or through tonal value or typography in a black-and-white publication.

6.2 Design principles

Inspired by Ben Shneiderman’s maxim “overview first, zoom and filter, then details-on-demand” (Shneiderman 1996), six models for the visualization of cultural history data are presented. An overview of the documentation on different levels is necessary in order to view the listing of all finds and findings, and also the outline of all the details of an artefact.

Schematic visualization is of little use for evaluation purposes in the conceptual phase. In order to test whether the graphics generate added value, these must be fully formulated and visualized by means of a small, but extant and impeccable dataset. One of the reasons why visualization is not

carried out immediately with a programming language (such as Processing) is the rigidity that results. A vector program (such as Illustrator) allows for the necessary flexibility during the creative development process.

6.2.1 The inventory [fig. 8]

The inventory, in the form of a text with illustrations, is the basis for further visualizations that are created by filtering data, or through different ordering methods and juxtapositions of the lines and columns.

André Malreaux's imaginary museum (Malreaux 1965) [fig. 9] or Aby Warburg's Mnemosyne Atlas (Schuller 2011) [fig. 10] clearly show how knowledge can be generated by graphic depiction (or visual memories), different degrees of proximity to the images and different constellations of them. The inventory makes all information visible on a single level. The tables harmonize the size of the reproduced objects.

Franco Moretti's method of "distant reading" (Moretti 2007, 2013) justifies the added value of a larger context as follows: "All you can see are swarms of hybrids and oddities for which the categories of literary taxonomy offer very little help. It's fascinating to feel so lost in a universe one didn't even know existed" (Moretti 2013, 181). Moretti argues against individual work on the text and in favour of numbering and mapping. Quantitative literary analysis is a good example of how data can be investigated from a different perspective and with different methods.

6.2.2 Charticle [fig. 10]

A "charticle" is a combination of text, images and graphics and corresponds to an independent article (chart + article = charticle). In contrast to a traditional newspaper article, the image and the graphic are not just used to support the information in the text, but are at the centre of the article. This visualization form allows a summary to be made of an object or a collection, rather like a finds label or an index card in an archive. The instrument panel summarizes the metadata in a profile.

6.2.3 Analogies [fig. 11]

Visualization methods are not exclusively quantitative in scope. If one thinks of the Mnemosyne Atlas by Aby Warburg, for example [fig. 10], this can be regarded as a means of creating image constellations, with Warburg's tables forming "utilitarian" images to be grouped and regrouped and which served to investigate the function of expressive values in the European Renaissance. The pictures distributed on the floor of Malreaux's imaginary museum provide, as it were, an archival grid in which reproductions of different periods, materials and object groups are juxtaposed. In this manner, relationships can arise between display objects, however far removed from each other they might otherwise be.

In archaeology, visual methods are often used for documentation purposes. For publications or for exhibition in a museum, the immense collection of image material is rarely used, however, being

instead transformed in advance and summarized in text form, or restricted to individual artefacts. These are thereby highly abstracted and wrested out of their geographical, chronological or formal typological context. Information graphics are created, taking the original documentation – thus the image itself – as their starting point. Illustrations or visual metaphors (Eppler 2003) use analogies (hence the word "datalogy" – see fig. 4) in order to communicate in a more varied, sustainable manner. Images remain longer in the memory. When using analogies, the graphics need less textual explanation because there are already points of contact with known material. The language is familiar and the user does not have to learn any new notation system.

6.2.4 Timeline

An elastic timeline allows one to view highly varied time periods and material quantities. "Not yet dated" is not the same information as "unclear" or "cannot be dated". The challenge to information graphics is to avoid creating something rigid that allows for false conclusions. Information gaps, uncertain or unspecified details have to be differentiated and characterised as such. However, this applies to all visualization models.

6.2.5 Map [fig. 13]

A map – as an abstract representation of an archaeological excavation site or a complex database – allows us a perspective that is too large and too complex for us to see directly (MacEachren 2004, v). The mapping of data does not refer exclusively to geographical data. Semantic or figurative maps also serve as aids to orientation.

Mapping a database allows us to see beyond the horizon on a reduced scale. Cartography uses a multitude of representation systems. Iconographical, geometrical, linguistic and formal conventions are applied with which to mediate data into pictorial representations (Fawcett-Tang/Owen 2008, 12). In order to define attributes, icons are employed. Text serves to describe specific characteristics. A matrix, also called a choropleth, divides the map into geographical or thematic boundaries. A network shows the interlinkages and relationships of the features to each other. Points mark exact positions, bubbles can alleviate the unambiguities, and coordinate axes create relations to the points and serve as aids to orientation. All these systems are characterized by the fact that a value on the system level is the same everywhere, and the levels can overlap. Places can be assigned signs, for example. Allocation (Cancik-Kirschbaum/Mahr 2005, 97f.) is an ordering of two separate systems of structures.

6.2.6 Network

The visualization of networks can allow data to be linked, whereby new, collective associations arise (Lima 2011). The more finely the data is linked together, the more stable the nodal system becomes. For the visualization, only individual attributes need correlate, not whole artefacts. The characteristics are assembled and interpreted according to context and usefulness. The concept of "actor-network theory", derived from the sociology of science (Latour 2007, 76), brings together

disparate connections of action and meaning for categorically different things, practices and participants as equally valid semantic links within a network of actors. Data networking avoids the occurrence of dataset doublings, and links the written documentation closer with the pictorial documentation.

7. Discussion

As became evident in the first part of this paper, documentation strategies are lagging behind general developments, which are tending away from the individual object to a more unified coverage of cultural history relationships. The potential for using collection documentation for analytical and communication purposes has not yet been exhausted. Using methods of data visualization, this article also discusses possible approaches and explains how knowledge visualizations can be utilized to help translate cultural history materials. The interdisciplinary field of information design – with its origins in communication design – transforms non-structured raw data into comprehensible information. In these methods, processual design is foregrounded, with functions such as analyzing, structuring, preparing, combining, transforming, ordering, managing and evaluating. Information design offers a vast potential for providing context, insight and perspective in the case of large-scale datasets. By combining quantitative and qualitative visualization methods, different, barely accessible data can be linked. New knowledge is generated by our being able to visualize new relationships and new contextual references. This paper presents basic theoretical knowledge about visualization methods and guidelines for its concrete application to cultural history collection materials, and describes an alternative method for the analysis and communication of archaeological data. We show that the act of visualization has a great influence on historiography. In future, we shall see how the epistemology of images influences scientific practice, how their communication influences the objects under investigation, and how new visualization forms influence the visual memory.

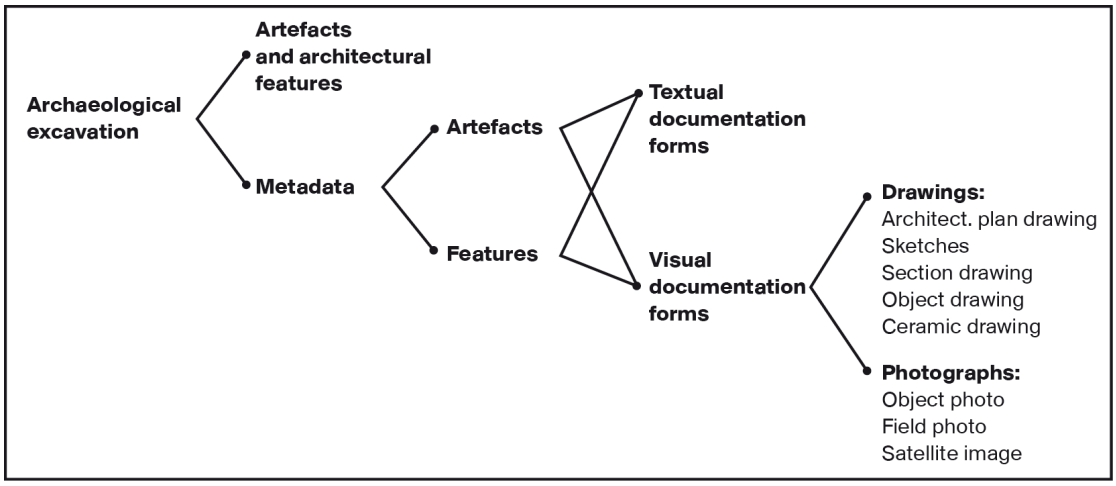


Figure 1: The tree diagram shows the structure of textual and visual documentation forms of an archaeological excavation.

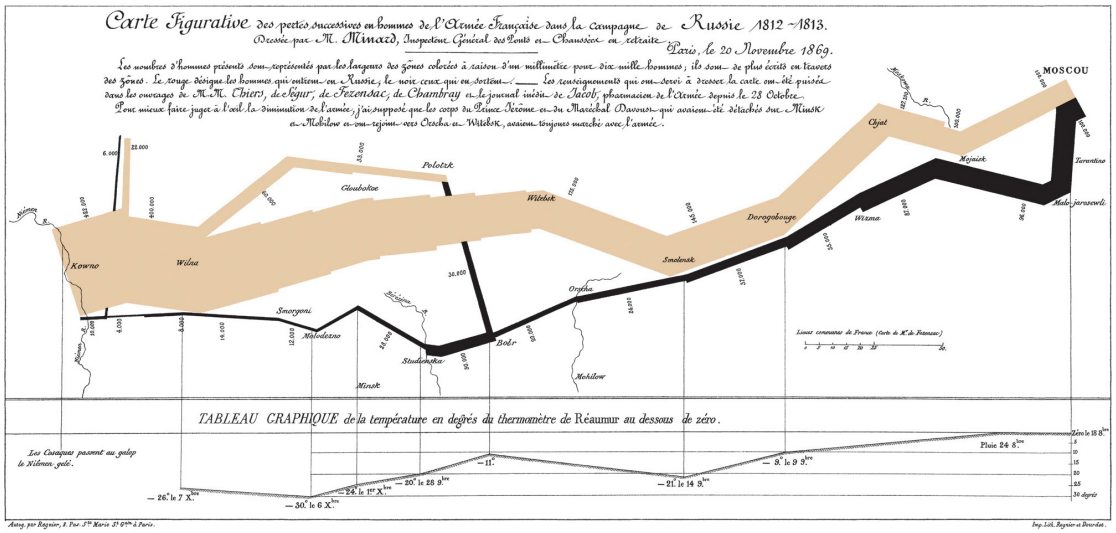


Figure 2: "Carte figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812–1813" by Charles Minard, from the year 1869.

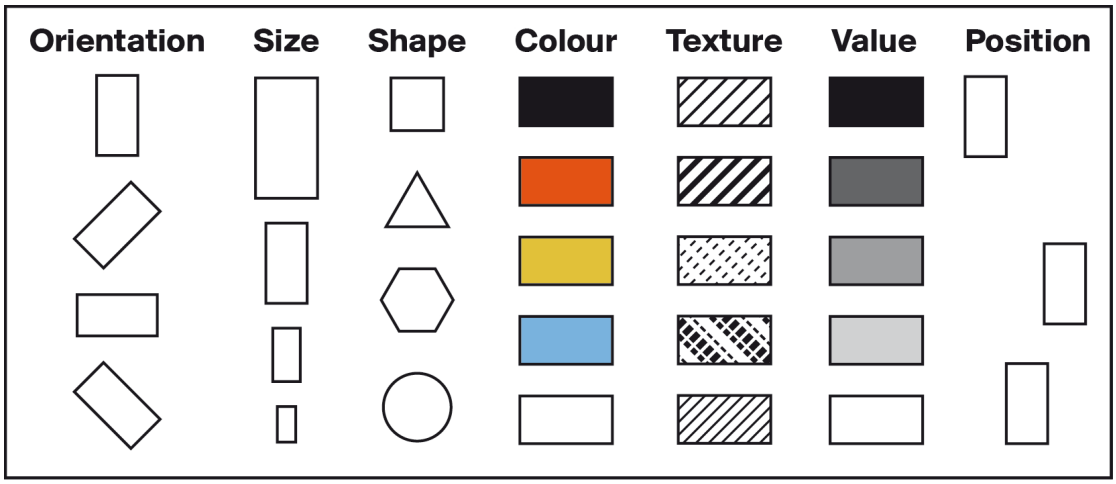


Figure 3: Graphic variables for grading attributes by Jacques Bertin.

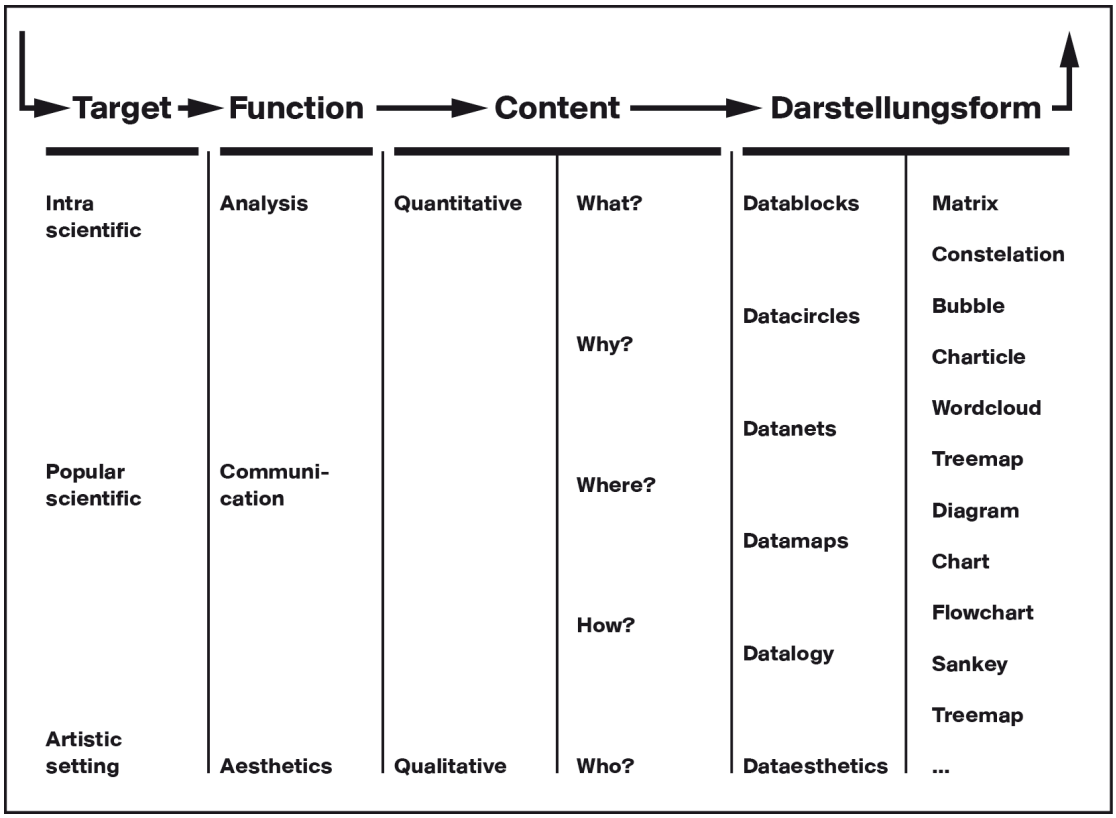


Figure 4: Reference system for creating visualizations.

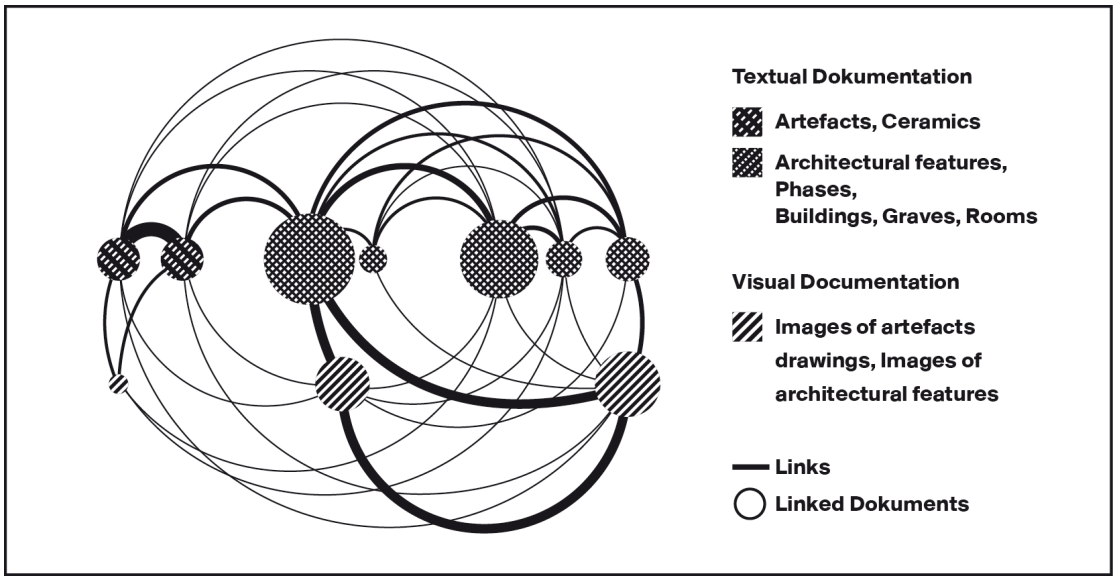


Figure 5: Structural diagrams of an archaeological database with links between textual and visual documentation, depicted in quantity flows. The bubble diagram included shows the linked finds and findings.

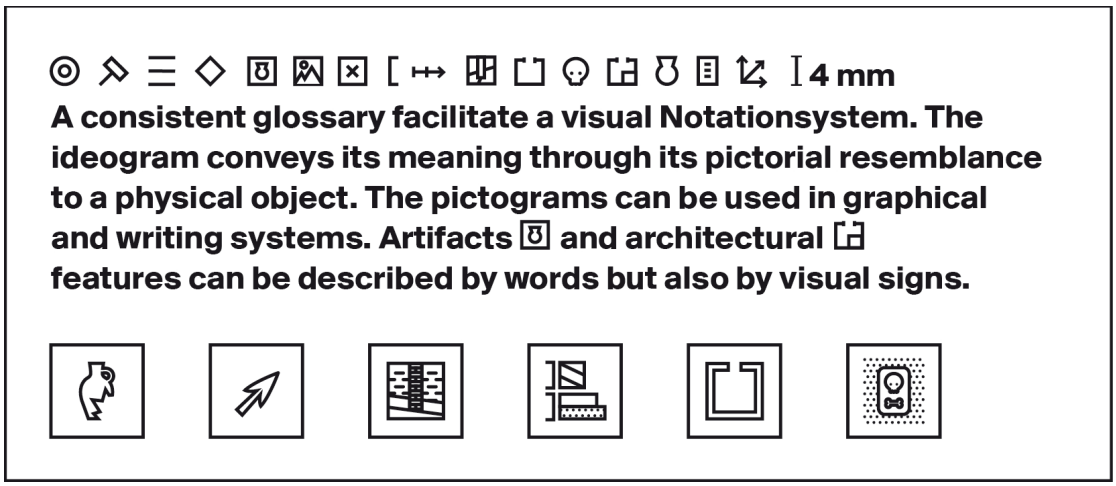


Figure 6: Visual reference system, independent of language.

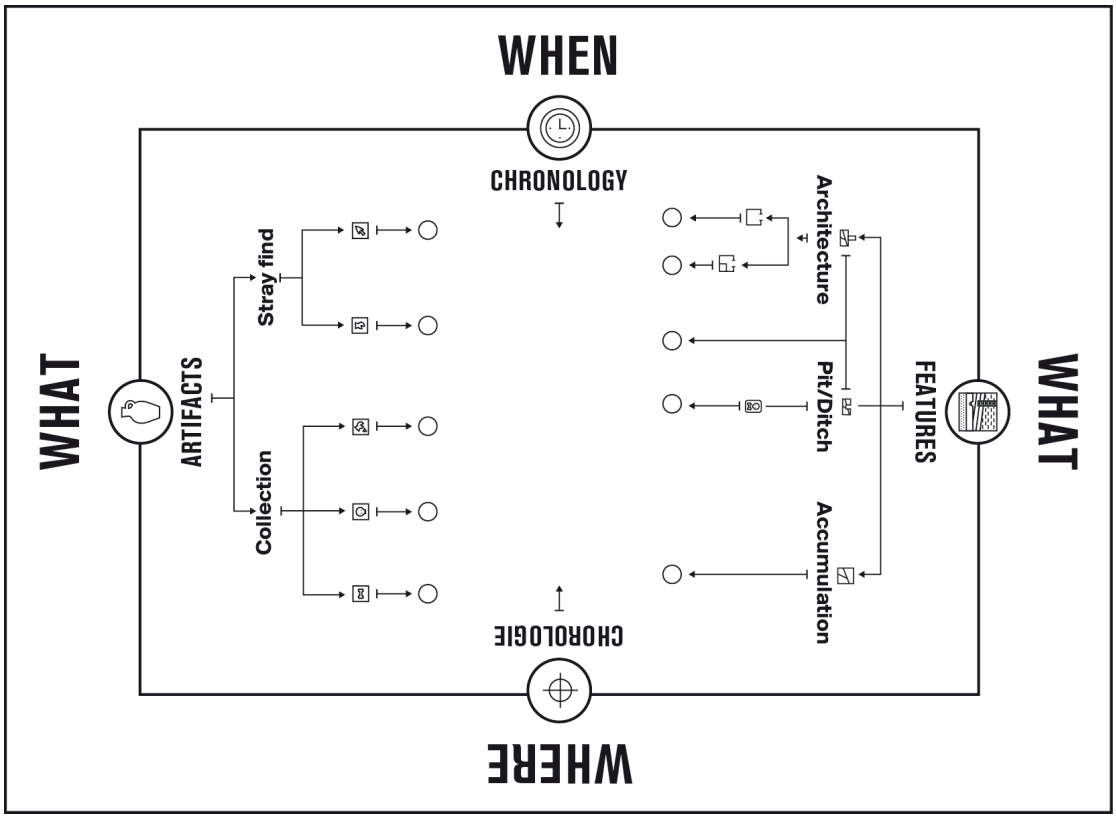


Figure 7: Playing field: a system of cultural history objects.

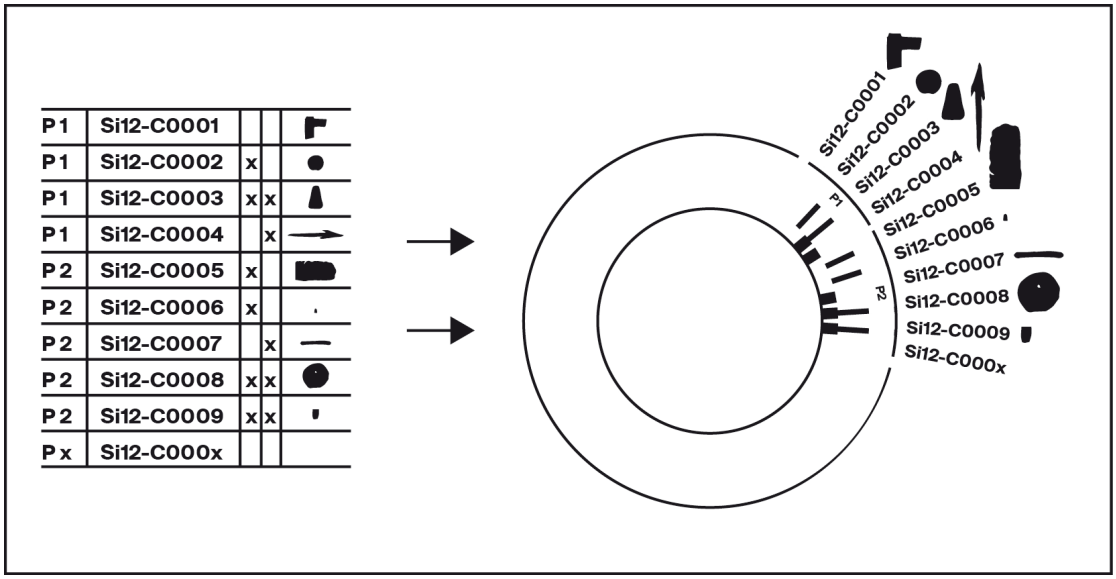


Figure 8: Table versus circular index.



Figure 9: André Malraux's "The imaginary museum" from 1950.
Image: Krauss, Rosalind: Das Schicksalsministerium, In: Wolf, Herta (Ed.): *Paradigma Fotografie – Fotokritik am Ende des fotografischen Zeitalters*. Bd. 1. Frankfurt/Main: Suhrkamp Verlag. 2002, p. 395.

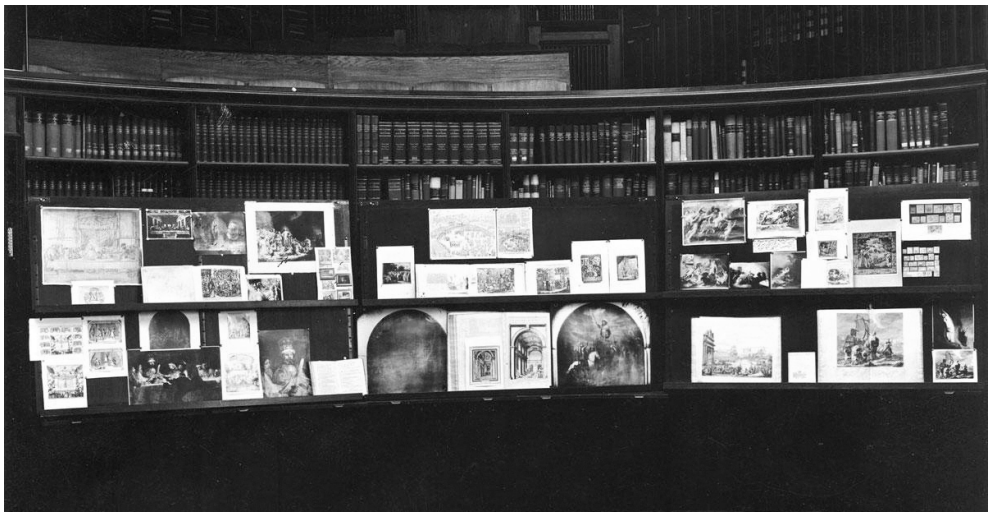


Figure 10: Aby Warburg's Mnemosyne Atlas, tables for the Rembrandt exhibition of 1926.
Image: Warburg Institute, London.

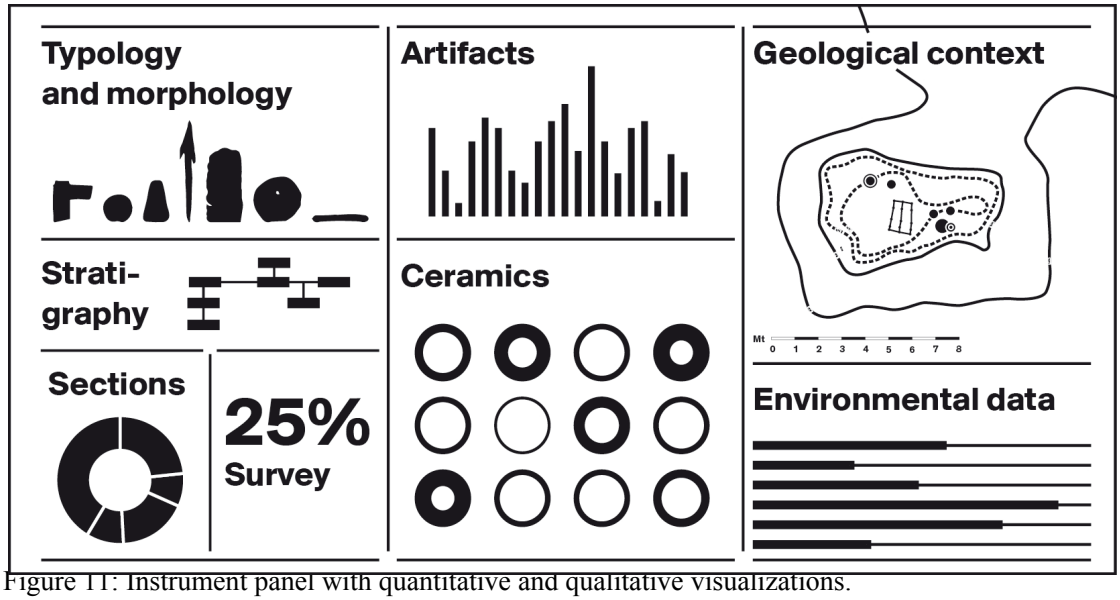


Figure 11: Instrument panel with quantitative and qualitative visualizations.

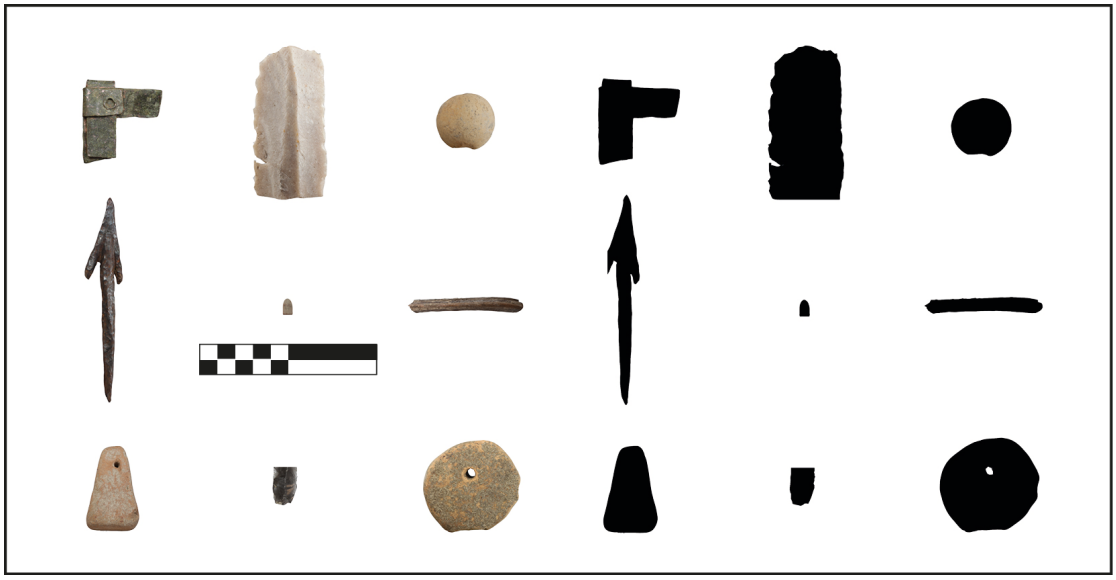


Figure 12: Visualization of a formal typological analysis (typology, materials, size, form).

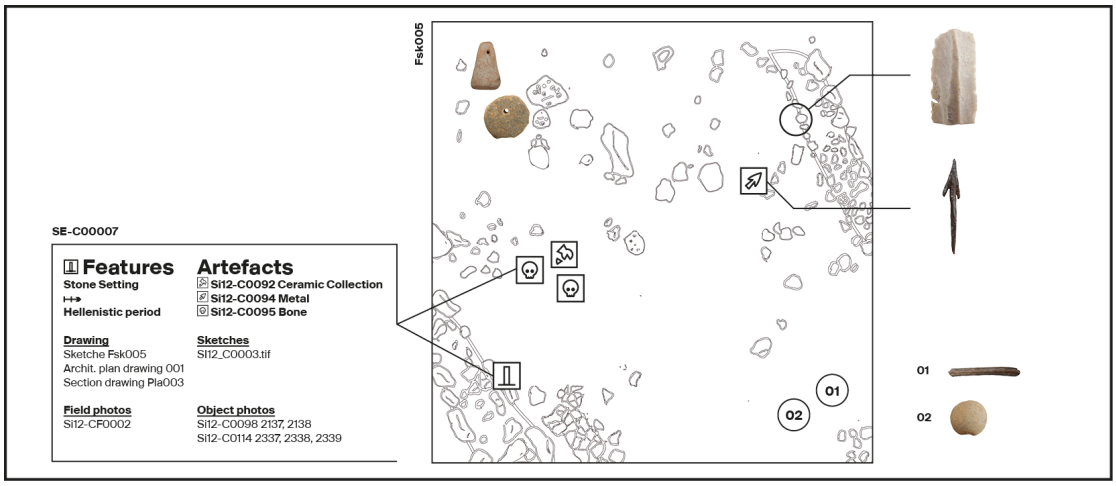


Figure 13: Map with four (direct and indirect) ways of pointing information on a archaeological drawing: Text-based, object-based, by connecting lines, by numbers.

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