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Proceedings of the 12th
European Academy of Design Conference.
Sapienza University of Rome, 12-14 April 2017
supplement of The Design Journal

edited by
Loredana Di Lucchio, Lorenzo Imbesi, Paul Atkinson

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The Design Journal
An International Journal for All Aspects of Design

ISSN: 1460-6925 (Print) 1756-3062 (Online) Journal homepage: http://www.tandfonline.com/loi/rfdj20

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To cite this article: Barbara Stabellini, Chiara L. Remondino & Paolo Tamborrini (2017) Data Visualization Collection. How graphical representation can inspect and communicate sustainability through Systemic Design, The Design Journal, 20:sup1, S1673-S1681

To link to this article: http://dx.doi.org/10.1080/14606925.2017.1352690

Published online: 06 Sep 2017.

Design for Next

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doi: 10.1080/14606925.2017.1352690

Data Visualization Collection. How graphical representation can inspect and communicate sustainability through Systemic Design

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Abstract: Big data are totally changing the business rules, the society, as well as the perception of ourself. The need of a big data oriented culture is becoming essential for everything that has an informative assets. Furthermore, technological innovation offers products and features unique that can help to convey values and meanings, for the purpose of communication based on increasingly strong interaction between people. In a world where everything is consumed in a short time, it is important to turn information as visual as possible, making simple what is complex. The visualization becomes a medium for increasing cognitive perception of the beholder, easing reasoning and storing of the information represented, showing patterns and relationships, known or not, maybe not easily visible without the aid of a visual representation of information.

Keywords: sustainability, systemic design, data visualization, complexity

1. Introduction

We are living in an era of exponential increase in data production, collection and usage in different sector and in everyday life moments; for this reason the ability to collect, understand, communicate and make sense of information is going to be a very important skill. In terms of sustainability, data produced by environment, both infrastructures and individuals become tools for reading the society, quantifying its sustainable and unsustainable aspects; the study and the analysis of such data is fundamental to better understand what may be the future action strategies in order to improve environmental, economic and social sustainability.

The growing interconnection due to the digitalization of information and relations, as well as the exponential spread of data generated by things, people and organizations, represent a challenge and an opportunity to design new tools suitable to complex and changing environment in which we live. Therefore, it is essential to understand how it is possible to extract the most value from information, emphasizing the communicative potential contained in them (Cukier, 2013).

In a world where everything is consumed in a short time, it is important to turn information as visual as possible, making simple what is complex. Data visualization becomes a fundamental medium to explore phenomena, encouraging thinking, information memorization and interpretation; in other words make complex phenomena accessible through visual tool. The transformation from data to information, anyway, is not that simple, but is a continuous improvement path where data are collected, categorized and contextualized in a specific ecosystem.

Because of the importance of this transformation, the discipline and the role of the design become essential. Nevertheless, today many works that can be included within the topic of visualization of the data is often the result of the lack of design or of a design that does not take into account an overview. For this topic, design is often considered a surplus, but the discipline should find space right here, by filling this gap, positioning itself at the beginning of within the design whole process, not just at the end, so as to be able to offer a complete design in all its stages, and not a simple and common add-on.

Specifically, the purpose of our research is find positioning in the beginning of the decision procedure, offering an important contribution in the selection of the correct type of visualization graphics, adapting and shaping to better define guidelines to analyze and broadcast informations with a sustainable point of view.

In order to achieve the best result in term of comprehension and communication, it becomes essential the creation of a multidisciplinary team; indeed, data visualization cannot simply be defined as the representation of information in visual form, but it is a complex multidisciplinary field (Card, 1999), ranging from data mining to visual art, from psychology of perception to graphic and systemic design.

2. Collection

The use of charts, graphs, maps, diagrams, and tables is not new; this kind of representation accompanied us in the course of human evolution in dealing with the history and the socio-cultural contexts, the spaces and the organization of our knowledge based on models more and more suited to our way of life and the way in which we feed of information.

2.1 Environment as a context

Always, the greatest experimentations and monitoring has been conducted into the environment. For this reasons it becomes of fundamental importance to keep track of all that surround us and being able to understand data that environment offers.

This scenario allows to assume that environment is the context. The environment, in fact, produces data from space to people, both analogic and digital as well as the intersection of them and their correlation. This data become raw material, on one hand enabling a continuous transformation, and on the other hand encouraging always more new projects and visions, shared only if make visible.

Always, the weather conditions monitoring interest people, scientists, amateurs and national or international institutes. The meteorological data, be they collected by professionals, citizens or sensors and other technologies, has been, and currently is, fundamental in an attempt to forecast meteo and global climate changes. The sailor observation has been of vital importance to develop the first ocean current and wind maps. It is possible to see a particular and interesting series of data in the captains on board diaries of the East India Company ship. In 1709, the Rochester ship sailed away from Great Britain to China and its captain kept a detailed diary with ship sketch, wild animal drawings and particular locations pictures, recording also all the information about position, path and meteo forecast. Today, the availability of huge amount of data, allows scientists to complete this work. Their images aren't only static maps, but are able to capture the dynamic nature of our global system. For example, the NASA visualization, shows oceanic currents thought satellite data collected between 2005 July and 2007 December, offering a dynamic overview, with significance and impact.

Also the healthcare field is strongly interested and involved in the data visualization; in fact, the graphic representation of the information is integral part for the healthcare improvement and the society well-being. History shows how sometimes the representation of harvested data could help to find causes and therapy diseases, as well as the tracking of infection rate and geographic distribution allow to monitor the epidemics diffusion or the identification of the local environmental factor that contribute to it. The most known and influential visualization in this topic is made by Dr. John Snow who tracked Soho deaths due to cholera in 1853 highlighting in a ghost map the water pumps of the area and crossing these data with the close deaths; in this way he could prove how epidemics didn't spread out by Thames, but by the water contaminated with human waste, thus strongly linking the healthcare question to the environmental one. Today, the healthcare data mapping continues to be very important, especially if connected with other demographic dataset: significative contribution in this regard is the work by the UK Chief Medical Officer that every year publishes an annual report in which there are mapped a huge number of mortality and morbidity, with the goal of offer a clear and objective overview on the national clinic situation.

Maps are a topic widely linked to mobility research, not only for what that concern path, travel indication and signs. The analysis and the visualization of tracked data by individuals, as by companies, can offer a particular reading of the around society. Since 1980, curious is the use of data from the UPS delivery company, which, through the initiative called ORION (On-Road Integrated Optimization and Navigation), started to track its vehicles, monitoring speed, direction, braking, and drive train performance. These data are not only used to monitor daily performance, but to redesign the route structures: this approach allows to reorganize the delivery path optimizing fuel consumption and, consequently, environmental carbon emission.

In the end, if we consider environment as the context, we can not refer to the energy issue, which is today one of the hottest topic, including consumption, discovery and implementation. The growing availability of energy data allows people to determines how they use them defining what is their impact on the environment, also linking these information with other dataset as public transport, technology, production.

2.2 Data visualization collection

In order to better collect, visualize and communicate data, for example as above mentioned, but not only limited at it, the literature reveals a lot of types of graphical representation from specific sectors (such as finance, economics, science or meteorology), but in terms of innovation and experimentation, all those forms can be applied in areas for which they were not designed, offering the expansion of the domains and purposes to which these practices are applied.

There are a lot of research which try to find the best way to classify graphics. One of the first characteristic of the existing taxonomies of graphs and images is the difference between functional or structural. Functional taxonomies focus on the intended use and purpose of the graphic material. In contrast, structural ones are derived from exemplar learning and focus on the form of the image placing more emphasis on emotions, rather than its content. In general this tendency arise from the distinction between the different experts's background, the firsts typically focused on statistics, computer science and engineering, while the second ones much more into graphic design and arts.

One of the most common and known example of functional classifications can be found in Edward Tufte. He identify four specific category in which classify graphics: the geographic representation through maps, the time-series, the graphic representation of events and phenomena which develop in space-time and the visualization of relations. (Tufte, 1983)

Also Heer, Bostock and Ogievetesky have put the emphasis on functionality in 2012; they proposed an articulated classification of graphics focusing on the experience of our times, and then paying attention on big data. Specifically, they identified four categories: time series, statistical distributions, maps, hierarchies and networks. (Heer, Bostock e Ogievetesky, 2013).

Different from a functional classification, Lohse et al. (Lohse, 1990; Lohse, 1994) classify visual representations using meaning and similarity between them. They identified six basic categories of visual representations: graphs, tables & time charts, maps & cartograms, diagram, networks, and icons.

In addition to taxonomies, there are a lot of catalog and table that collect the visualization methods. One of the most known book that collected and explain the use of each single type of representation is the manual of Harris (Harris, 1996). Another example is the Periodic Table of Visualization Methods (Lengler, 2007). This kind of classification aims to be less academic and draws on fields such as chemistry for his famous periodic table of elements. The periodic table is an interactive and prototypical example of Ben Shneiderman's visualization mantra of Overview first, zoom and filter, then details on demand. (Shneiderman, 1996). The visualization methods are categorized in data visualization, information visualization, concept visualization, metaphor visualization, strategy visualization and compound visualization. All graphics are then specified according task and interaction (overview, detail, overview and detail), the cognitive processes (convergent thinking, divergent thinking), and the represented information (structure, process).

Starting from the fundamental taxonomy defined by Tufte and the most common basic classification by Lohse et al., we collected 96 visualization graphics trying to offer a comprehensive collection. As it is possible to see in figure 1, there are many type of graphics, some of these unknown to many people, due to their specific field of use.

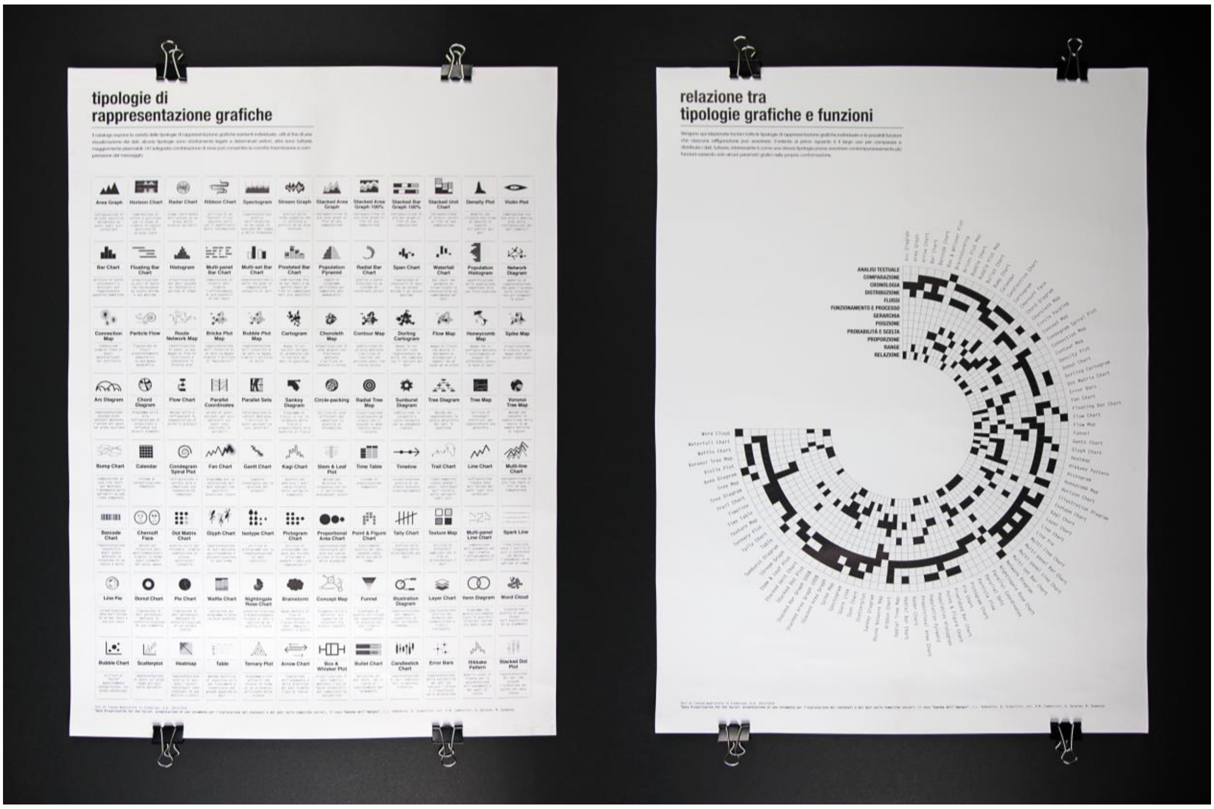

Figure 1. Collection of the types of representation and their functions.

Except for particular type of representations, the other ones can be used for different kind of data; nevertheless, it remains essential the right choice of the graphics in order to achieve the graphical excellence which consists of complex ideas communicated with clarity, precision, and efficiency. (Tufte, 1983; Cairo, 2013).

However, the importance of communication and the message that visualization itself should convey bring attention to move on the functions that these representations can perform. In order to allow this process, we identified twelve function to which a visualization have to perform, and we tried to relate each chart to each function defined: text analysis, comparison, timeline, distribution, flows, operation/process, hierarchy, location, probability/choice, proportion, range, relationship.

It's important to specify that each representation can be generally used to perform many functions, both in different projects and at simultaneously in an only-one visualization. An example can be the word cloud, a representation in which words that appear most frequently are larger and words that appear less frequently smaller, this is normally used for the text analysis, but at the same time it can highlight concepts by using dimension of the words, or put them in relation by space disposition.

3. Context and relations

Nevertheless, the identification of the right representation is only a part of the process. Data on their own do not say anything, they should be placed in context, correlated with each other or with other datasets to identify distributions, sizes and correlations; they have to be sorted and aggregated according to designed criteria.

To do so it becomes essential the analysis of the initial data and their inclusion in the context, properly related to each other and/or with other datasets to identify distributions, sizes and correlations, sorted and aggregated according to criteria to the search.

As Tufte wrote, context is essential to reply to the question “Compared to what?”. In fact, graphics must not quote data out of context and context is essential for graphical integrity. (Tufte, 1983)

Speaking of which, Wurman suggest that one of the main purpose of information representation is to help users avoid “the black hole between data and knowledge”; thanks to the relation with the context, unstructured information (reality and complexity), can be encoded in structured information and then knowledge and insights for a more conscious data driven decision making process, according to the DYKW hierarchies model (Data, Information, Knowledge, Wisdom).

Take into account context means also analyze users interested to the visualization, in order to offer a representation with a complexity level suitable to them and to answer the question “Do you know what it all means?”. In fact, basically there are two factors that influence the process of communication between the designer and the reference users: how the visualization used is well adapted to encode information on the nature of the story that you want to tell, and the background and knowledge of the reader about the argument represented. (Cairo, 2013).

Thus, information visualization is used to clarify and simplify information. It enables exploration of complex data, and can be used as a tool to persuade and convince observers of an idea by making information visible, highlighting the causes and effects of specific choices, comparing the different values and situations, showing the flow of a system and how it changes, analyzing the relations, distributing chaotic data into an ordered structure (Cairo, 2013; Shneiderman, 1996).

The design model used, known as Systemic Design (Bistagnino, 2011), pays attention to the organization, optimization and understanding of every single factor at play focusing at first on user requirements, then highlighting the best conditions and the most interesting facets to work on, while keeping an eye on their mutual relations. The focus moves from the simple sum of many elements towards a better understanding of the links between them and their strength, trying to balance functionality and aesthetics.

4. The role of design

To many people, information graphics are the images used in presentations throughout formal meetings or the graphs used in reports or newspaper articles. Many are used for these purposes; however, for each chart, graph, map, diagram, or table used in a presentation, there are others that are used for what that are called operational purposes. Representations for operational purposes are used by millions of people everyday for improving their efficiency and effectiveness, improving quality, solving problems, planning, teaching, training, monitoring processes, studying the geographic distribution of data, looking for trends and relationships, reviewing the status of projects, developing ideas, writing reports, analyzing census data, studying sales results, and tracking home finances. (Harris, 1996)

However, because of its historical roots in scientific reasoning, in academic research advanced information visualizations is often interpreted and characterized as scientific tools; the focus is therefore directed only to the functional requirements, not paying any attention to the aspects of user experience and graphic aesthetic.

In recent years, given the accessibility to the public of a great number of data sources as open data and environmental report, and the impact of that argument on the communication, the number of designers involved has increased, heavily impacting on the data visualization features. Information visualization is becoming more than a set of scientific tools to understand large data sets, but it is emerging as a medium in its own right, with a wide range of expressive potential and its goal is to transform data into information and information into insight (Fiorina, 2004).

As in most other design-related fields, information visualization seeks to achieve a balance between the requirements of utility, soundness and attractiveness. Utility corresponds to the classic notions of functionality, usability, usefulness and other quantitative performance measures; these aspects generally define the effectiveness and the efficiency of the visualization. Soundness is concerned with reliability and robustness. Attractiveness refers to the aesthetics aspect: the appeal or beauty of a given solution; aesthetics does not limit itself to the visual form, but also includes aspects such as originality, innovation and user experience. (Moere, 2011)

If we take into account this requirements, the relation between design and information visualization become clear, and also become clear the importance of the design discipline during all the process: in fact, it is not an activity that can be added later.

But we want to underline the importance of the key background focused on sustainability. The goal of any data visualization design is rethink constantly both the workflow and the language in order to increase knowledge and understanding to enabling always more conscious behavior. It follows the importance of a network of actors involved in the project; networking is, in fact, considered essential for the growth of an ecosystem because of cooperation and inclusion processes help optimally managing the project and the goal pursuit.

5. Conclusions

Today, an increasing number of organization and corporation, as well as single users or public administrations, are realizing that volume, velocity and variety of data require always more new application. More than technology, though, they should adopt a different mind-set based upon data discovery and exploration; the visualization itself should be seen as a technology (Cairo, 2013) as an extension of ourselves. A good project has two main goals: it present informations and it allows user to explore and discover them; in other words data visualization is a tool for the designer to communicate with users and an instrument for users to analyze the reality presented.

In this way the role of the data visualization is to activate the attention and analysis process and generate order before people's brain try to do it. Thus, the visualization becomes a medium for increasing cognitive perception of the beholder, easing reasoning and storing of the information represented, showing patterns and relationships, known or not, maybe not easily visible without the aid of a visual representation of information.

On the role of the design is important to remember that the function constraints the form and that the graphical elegance is often found in simplicity of design and complexity of data; graphics should not simplify message. They should clarify them, highlight trend, discover pattern and show hidden reality.

The postmodern personality is fluid, complex and dynamic, and the needs of the people are always new; the different identities have different approaches to technology, communication and information. For these reasons, it becomes highly interesting to give the possibility of obtaining results by ensuring the personalization experience, with the aim of satisfying the different needs and driving the user to repeat his behavior.

In this context, information visualization can be a valuable tool to improve communication, to offer a higher level of information, but even to allow users a personalized path. All this can be applied to different contexts coming to assume the role of cultural analysis tool for discovering and understanding data, decoding the complexity of contemporary society and abilitate always more new sustainable and innovative practices.

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