

How and why it works:

The principles and history behind visual communication

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Abstract

"A picture is worth a thousand words" – a familiar adage, and the reason why newspaper articles are commonly accompanied by photographs and infographics. Scientific publications are no different, so medical writers are frequently asked to contribute to the design of figures and visuals. There is therefore a growing need for medical writers to expand their skills to include designing graphical abstracts, scientific figures, and infographics. This article explains the basis of visual perception and information architecture, provides some examples of biomedical information design, and explains how aspects of design theory can be applied to create effective infographics and other visuals.

Visual perception and the power of imagery

Light – either emitted by objects or reflected from their surfaces – enters the human eye where it is converted into electrochemical signals. The rods and cones that populate the retina are tuned to respond to sets of visual attributes to different extents.¹ Signals from the retina are then transmitted via the optical nerve to the brain and converted into meaningful information based on previous experiences and information. Perception has a physiological and a psychological basis and – while there may be only one reality – perception is unique to the individual.



Figure 1. Lascaux cave paintings

This individual aspect of information processing makes perception a subjective process; it is a deformation of reality, in which part of the existing world is captured and the rest is discarded. In short, although our sensors detect stimuli, it is the brain that makes sense of it. Surprisingly, an estimated 50–80% of the human brain is dedicated to visual processing, including vision, visual memory, shape discrimination, spatial awareness, and image recollection.²

Humans are constantly drawing from previously acquired knowledge and experiences when processing visual information, thus can be considered pattern recognition machines.³ To put this into

perspective, consider that our brains do not differ greatly from our ancestors'. In the early days of humankind, perception was vital for functions such as hunting (motion detection), food collection (colour recognition), and tool construction (shape recognition). It is therefore not surprising that images have been used to communicate since prehistoric times. The cave paintings in Altamira and Lascaux (Figure 1) were made 20,000 to 40,000 years ago, and by 3,000 BC, Egyptian hieroglyphs had been developed as a language. In the last two millennia,

powerful imagery has been used in church paintings and in Bible illustrations to spread the Christian message.

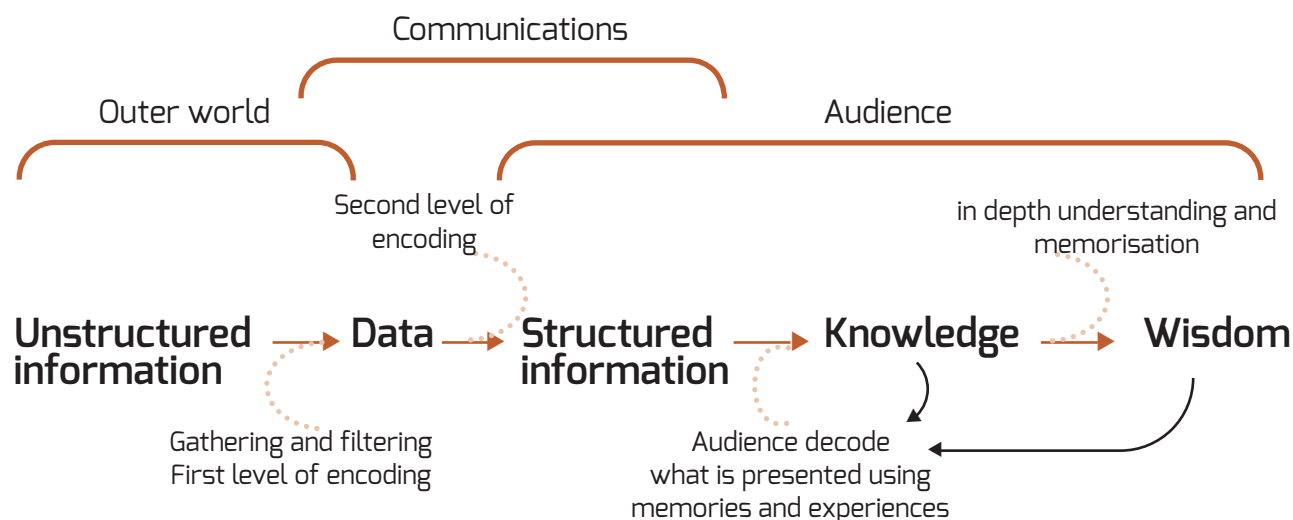


Figure 2. The Data-Information-Knowledge-Wisdom cascade

This scheme illustrates the process by which communicators organise data into multiple structural levels, so that information can be transmitted and assimilated by an audience. The progression is accompanied by a decrease in the entropy of information and increments in its value.

Infographics and information architecture

Visual communication is the norm rather than the exception. However, in an increasingly complex world, it has become a challenge to convey the essence of highly complex data in compelling visualisation that summarises all of the relevant information. One of the most widely used approaches to this challenge is to use infographics, which have been applied in many fields.⁴

Infographics are graphic elements that combine data visualisation (visual representation of numerical values), illustrations, text, and images in a format that tells a full and captivating story. Infographics are effective tools for communicating because they employ three key characteristics: pattern recognition (visual perception), the language of context (multiple variables shown in comparison to each other, allowing the magnitude of the effect to be conveyed), and picture superiority (pictures are remembered better than words).³

Although infographics are an old concept, their popularity increased during the 20th century because of their use in newspapers and magazines.⁴ Thanks to the enormous increase in data available due to computing and the demand to create easily digestible visuals, the use of

infographics by classic and modern media has exploded.⁵

When developing infographics, many designers make use of *information architecture* – a term coined in 1975 by Richard Wurman – to describe the art and science of design solutions for unstructured information.⁶ His ideas for structuring information are illustrated in the so-called Data-Information-Knowledge-Wisdom cascade (Figure 2). In the first step of the cascade, also referred to as the information encoding level, unstructured information (i.e. reality) is organised into a collection of observations represented by numbers and words. In research terms, this is referred to as data generation. At the second encoding level of, data is further structured using visual elements to reveal patterns or, in other words, to create meaningful content.

Information consumption by the receiver is not a passive process: when people see, read, or listen, they assimilate content by relating it to their memories and experiences. The goal, however, is to gain wisdom – the deep understanding of acquired information – and apply it to other situations.⁷

Information architects are thus facilitators in knowledge construction: they convey information in a simple way through words, visuals, or

both, simultaneously. The same might be said about medical writers, who also make complex information accessible to a broader readership. However, conveying information in a simple way does not imply losing information. As illustrated by the iceberg analogy: while just the tip of a visual design (e.g. visual elements, colours, fonts) is seen, a lot of work remains under the surface. The majority of a designer's and medical writer's work lies in understanding the needs of the audience, and the aim is to make life easier for the information consumer.

Visual information in biomedicine

Data visualisation is of course a key part of communication in biomedicine. Visuals such as line plots and bar graphs are employed to rapidly convey information. These and other simple types of data visualisation were first invented by William Playfair (1759–1823) to support his economic and political activities. Over the years, they have become essential for communicating in many different fields, including biomedicine. For example, in 1854, by combining graphs with conventional maps, the renowned English physician John Snow was able to summarise reported cases of cholera in the Soho area of London (Figure 3). This allowed him to trace the



Figure 3. Map taken from a report by Dr John Snow, showing the spread of cholera-induced deaths from a contaminated water pump in Broad Street, London

pattern of the disease and convince the local authorities to disable a water pump that was the source of contamination. Thanks to this innovation, he became known as one of the fathers of epidemiology.

The diagrams used by Florence Nightingale in the 1850s further illustrate the importance to biomedicine of expressing data visually. She was a nurse and invented the “rose” chart while examining the causes of death of soldiers in the Crimean War. The charts revealed that, due to poor sanitary conditions, more people were dying from preventable diseases than from war injuries (Figure 4). Using these charts, it was possible to visualise matters affecting the health of British Army soldiers and inform the hospital administration of the problem, helping to lay the foundation of modern nursing.

**Information design
is nothing more than
learning how to make use of
the magic of communication
through images.**

The impact of visuals in scientific communications

The increasing number of scientific publications and information generated have led to new trends in publishing, including the emergence of new scientific publishers and novel platforms for communicating science. Scientists also need new ways of attracting attention to their research and must help their readers wade through the massive amount of information available.⁸⁻¹⁰ Infographics are well suited to this role because they can be more effective and attractive than traditional graphics for presenting information. For example, several publishing groups have introduced the concept of a *graphical abstract*, which

is an infographic summarising the paper in a single image or cartoon-like visual.¹¹ Graphical abstracts are excellent tools for disseminating research on social media platforms and can be used

by both scientists and non-specialists. According to some authors, visual design improves the perception of intellectual and scientific proficiency.¹² They can also be used to effectively convey the benefits and real impact of science to fellow scientists and society, which is important for obtaining research funding. In recent years, graphical abstracts have become popular, and publications that include graphical abstracts and visuals have attracted more readers and generated more citations than those that did not.¹³⁻¹⁵

Applying Gestalt theory for publications: What medical writers can do

Just like a language is made up of letters, words, spelling, grammar, and syntax, visuals are also made up of several basic components: dot, line, shape, direction, value, hue, saturation, texture, scale, dimension, and motion.¹⁶ Researchers and medical writers can combine these elements to build a strong and clear message by showing

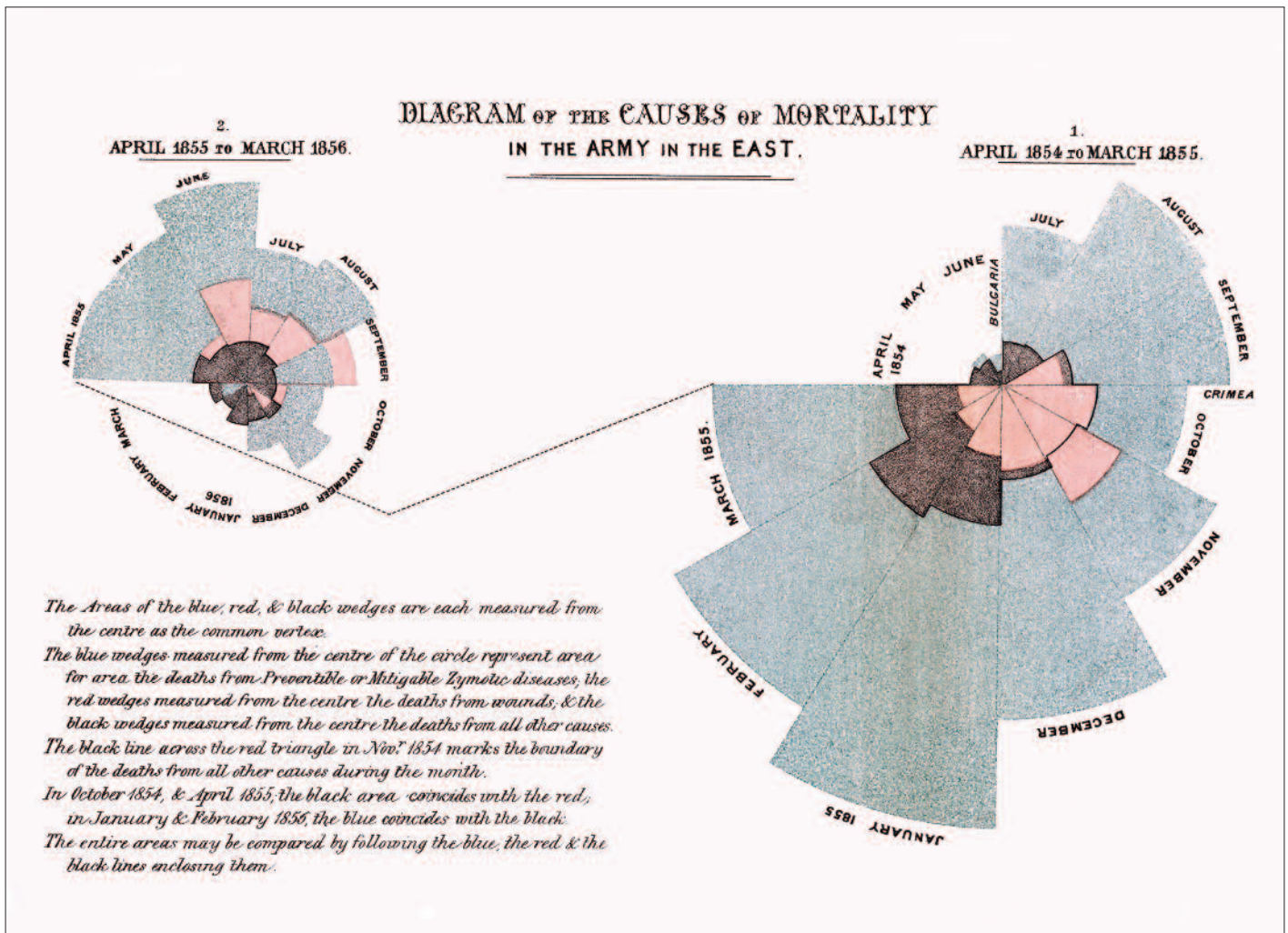


Figure 4. Rose chart originally drawn by Florence Nightingale during the Crimean War showing the proportion of deaths caused by preventable diseases (blue), by wounds (red) and due to other causes (black)

comparisons, trends, or proportions. Understanding can be further strengthened by organising these elements in terms of sequence, proximity, and hierarchy in the overall composition. But when doing so, what is known about the optimal way to arrange the elements in such visuals should be taken into account.

In the 1920s, the psychologists Max

Wertheimer, Wolfgang Kohler, and Kurt Koffka made key contributions to this field, leading to the foundations of the Gestalt theory. This theory postulates that the human brain tends to organise visual elements into groups. This led to the premise that “the whole is other than the sum of the parts”, whereby the emergent entity is distinct (not greater or lesser) than the sum of the parts.¹⁷

The processes of subtraction and simplification in visual compositions, although counter-intuitive, are essential for easing interpretation of visual information and keeping the focus on the main message.¹⁸ Arranging elements properly in space according to specific principles such as similarity, continuity, and proximity, can add additional layers of meaning without having to

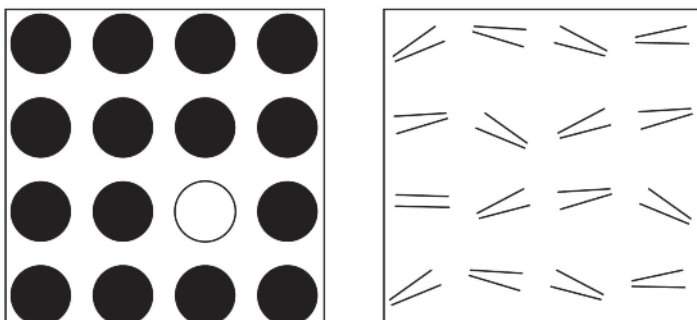


Figure 5. Visual compositions that trigger different mental processes: pre-attentive and attentive processing

Both panels contain a single element that is distinguishable from the others in the group. The speed at which the element is recognisable relies on the fact that certain graphic cues are stronger than others. As such, colour (on the left) triggers a pre-attentive, and faster, recognition process, while direction (on the right) requires an attentive and concentration-demanding recognition process.



turn everything explicit (e.g., objects that are close together are recognised as a group).

Gestalt theory can be used in many different sorts of visualisations, also when developing images for research papers. By making good use of the theory, a collection of graphs and panels from a research paper can be optimised into a more powerful and intuitive depiction of a story (Figure 5). Smart use of colour and layout can make the whole figure look more balanced and distinctive to a reader's eye.

Another way of making visual perception more effective is to exploit so-called pre-attentive processing. This mental process is extremely fast and enables us to recognise a large number of basic visual traits simultaneously. It is done in parallel (as fast as 200–250 ms), in contrast to attentive processing, which is done serially and engages the conscious part of perception and is therefore much slower.² In other words, engaging pre-attentive processing allows one to see something before *really* seeing it. Again, this can be triggered by making good use of the basic elements of visual communication.

Pre-attentive processing should therefore always be used in infographics and data figures to quickly guide the reader to the most important information. Moreover, because pre-attentive processing works so effectively, it is useful to

identify the basic visual elements of an infographic in a separate, early phase of the design process.

Conclusion

Information architecture aims to attract and inspire so that the viewer can reflect on the underlying data and use it further. To ensure the message reaches the target audience, authors should combine appealing aesthetics and knowledge of how information is perceived with the expectations of the viewer. A successful communication process therefore relies heavily on user-centred design, pre-attentive attributes, and Gestalt principles. Following these rules will inevitably lead to clear, effective, beautiful graphics that will inspire the audience.

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Conflicts of interest

The authors declare no conflicts of interest.

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