Big Data Analytics

COMMENTARY Open Access

From ancient times to modern: realizing the power of data visualization in healthcare and medicine

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Abstract

Data visuals (scientific images) display and express various amounts and types of information, and, as the saying goes,"an image is worth 1,000 words." Based on a review of two studies, a new estimation of how many words an image is actually worth was calculated in an attempt to quantify the complicated biological process of image perception. The result revealed that an image is actually worth more than 30,000 words. This new value estimation provides insight into the power of images. Given that figures, graphs, and data visualizations are types of images commonly used in research and publications, every produced figure is important and must be carefully considered during the publication process.

Keywords: Visual communication, Information graphics, Descriptive figures, Visual perception, Knowledge translation

Introduction

With a quick look at history and now, we can see that images have played an important role in transferring ideas since the beginning of humanity. It is rare to find a long-standing civilization, such as the ancient Egyptian civilization, that did not visualize their progress and contributions. For example, the ancient Egyptians drew their medical instruments in a very organized style on their walls, as you can see in Fig. 1. Even though there is no color in Fig. 1, the visualization transferred the message to the audience in a simple and effective manner. By looking at Fig. 1, we can extract a lot of information, such as that the medical knowledge in ancient Egypt was evolved and that they had advanced knowledge of human anatomy. Also, the small tools show that they had a general idea of the location in the body of the inner organs and how to do small incisions. There is no doubt that visualizing the medical tools was enough to show medical advancement and that the knowledge was passed on to the practitioners of medicine over the years.

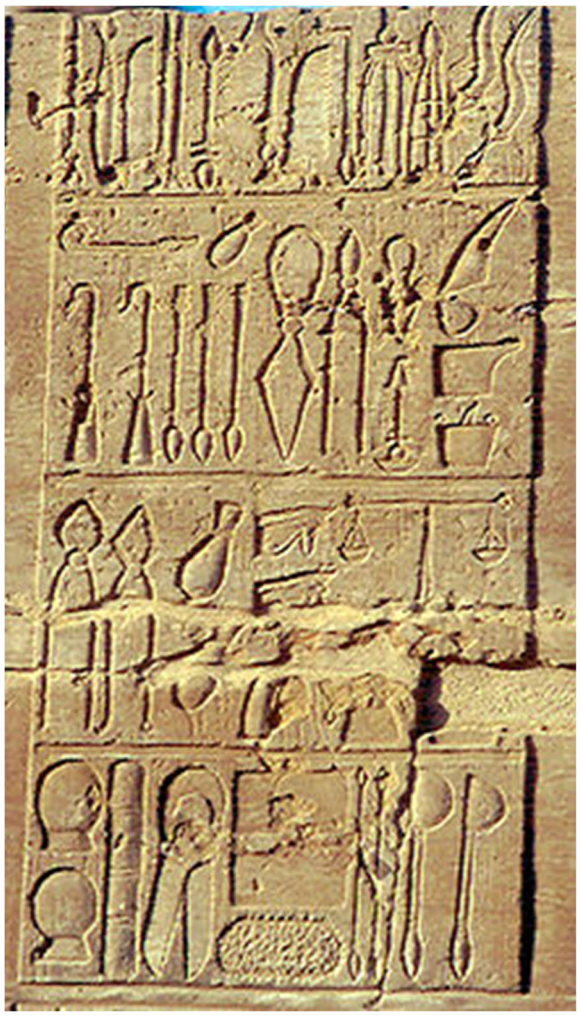

Fig. 1 Ancient Egyptian medical instruments depicted in a Ptolemaic period inscription on the Temple of Kom Ombo

From each medical instrument in Fig. 1, we might think of how many diseases they were able to diagnose and what types of surgeries they were able to conduct. We could write many words on each instrument based on this data visual; the question is, how many words could we write? This is the main question behind this article. We will try to answer this question in the next sections. However, before answering this question, we will discuss the recent literature confirming the importance of an image.

Recent research confirming image impact

In 2009, Dansereau and Simpson [1] suggested that images that include node-link graphic representations can enhance communication among clinical research, counseling, supervision and training, and organizational functioning. However, they did not quantify what an image was worth in terms of words; rather, they were confirming the importance of an image for knowledge translation. In 2012, Wechsler [2] mentioned the importance of images for Endovascular therapy. He confirmed that it is logical that understanding the physiology and anatomy through imaging modalities will improve endovascular therapy

and reduce morbidity. However, he did not quantify what an image is worth in terms of words; rather, he was confirming the importance of an image for Endovascular therapy. In 2013, Lorena et al. [3] hypothesized that images showing rooms owned by individuals with hoarding disorder would cause the owners to be judged as having a higher amount of possessions, being less tidy, being less functional, having a higher number of different classes of items hoarded, and being less clean than the owners of rooms in pictures showing healthy collectors. Their results showed that it is useful for the clinician to ask for images to help in diagnosing hoarding disorder when a home visit is not feasible. However, they did not quantify what the images were worth in terms of words; rather, they were confirming the importance of an image for tackling depression and anxiety. In 2016, McLoughlin and Ripley [4] questioned the usefulness of a Nomogram as a data visual to determine the probability of a clinical event occurring in a given patient. However, they did not quantify what the data visual was worth in terms of words; rather, they were trying to show the lack of validation of the Nomogram.

In 2016, Hales et al. [5] investigated the power of images for weight loss. They found that the use of images to self-monitor dietary intake and receive feedback has the potential to reduce user burden for self-monitoring. However, they did not quantify what the data visual was worth in terms of words; rather, they were trying to show the impact of images for weight loss.

Quantification methodology

The common saying "Use a picture. It's worth a thousand words," which first appeared in a 1911 newspaper article [6], is often used without much thought regarding its meaning or origin. A similar phrase, "One Look Is Worth A Thousand Words," appeared in a 1913 newspaper article [7]. Now the main questions here are why was this specific number (one thousand) used? and is there any scientific basis for this claim? Scientists are trained to question any given value and the certainty of such a value, which is what prompted this investigation. In 1977, Blackwell [8] asked the same question: How many words is a picture worth? He designed a primitive scientific experiment asking participants to describe in words the same information expressed in a single diagram by others. The results of his experiment, based on the average number of words used by all participants, were that a picture is worth 84.1 words. However, the images provided to the participants were simple black and white diagrams.

In 2020, we will try to address and answer the questions raised by providing a rough estimation (a more realistic estimation of this number) based on two recent studies: an invasive study and a non-invasive study. In the first study [9], a guinea pig retina was attached to an array of electrodes while images were flashed. Based on the generated response from the eye, they estimated that an image transfers information to the human retina at a rate of 8.75 megabits per second (Mb/s) (we can say that the speed of processing an image is 10Mb/s). The second, non-invasive study [10] found that the rate at which the brain receives and processes an image is 1.5Mb/s. Now we need to know the speed of reading words, here is a study [11] showed that the reading rate can be as fast as 300 words per minute (wpm). If we assume that each word is processed at a speed of 10 bits per second in our brain—based on the study published by Dijksterhuis and Nordgren [12], then the speed of reading a word is 50 b/s ([300 wpm] x [10 b] / 60). Note that the quantification process provided in this paper is based on the English language, and the language

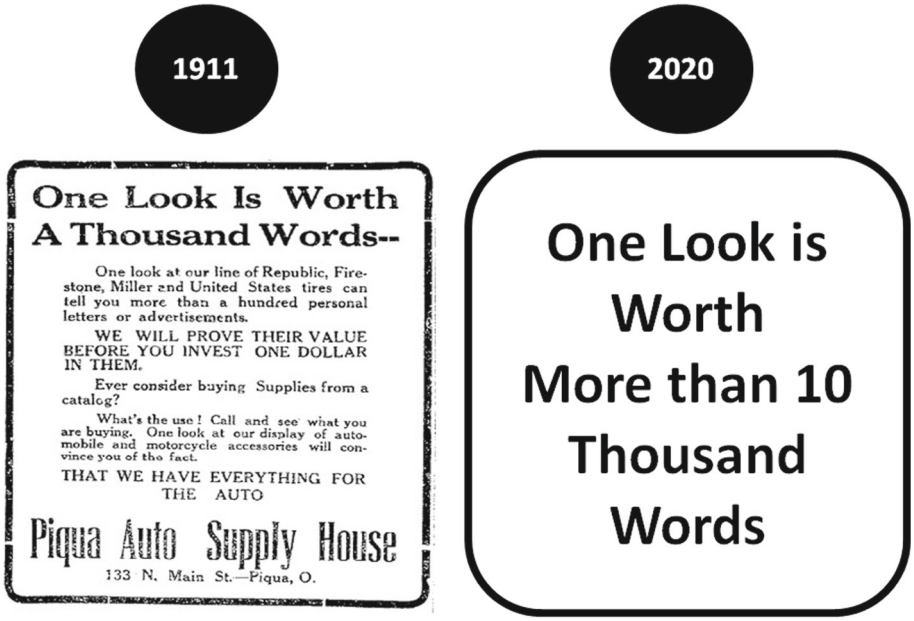

Fig. 2 How much is an image really worth?

of choice may slightly change the assumption and calculation [13]. We can calculate an estimation for how many words an image is worth based on each of the studies. In the first study, one image is worth (i.e. equivalent to processing) 200,000 words (calculation is based on [10 Mb/s] / [50 b/s]), and in the second study, one image (200 x 300 pixels) is worth 30,000 words (calculation is based on [1.5 Mb/s] / [50 b/s]). Based on these calculations, we can conclude that one image is worth at least 30,000 words and up to 200,000 words. Figure 2 reflects a change in the understanding of how many words an image is worth.

Relevance of quantification

The resulting estimation derived from these calculations is a simplified value that attempts to quantify the complicated biological process of image perception, and it provides some insight into the power of images used to convey information. For example, brain images are believed to have a particularly persuasive influence on the public perception of research on cognition [14]. Considering that we can now estimate that an image is worth over 30,000 words, the importance of this finding can be illustrated by using the analogy of a thesis. Often, the word count for a dissertation for PhD students in the Faculty of Education at the University of Melbourne needs to be 30,000 words or more [15]. Thus, when producing an image that summarizes a concept or idea, it can be as powerful and impactful as a written thesis. Morrison and Vogel [16] reported the equal impact of different data visuals (pie charts, boxplots, and info graphics) or images for persuading audiences. This is interesting because in the scientific realm, charts are considered images; however, scientists often produce images without always paying attention to their quality and impact [17]. Considering that these images are intended to clearly convey specific concepts and results, scientists must appreciate the real value of a produced image and focus their efforts into creating effective, impactful, and intentional images. With the proper application of data visualization techniques, scientists can elevate their work

and the impact of their results if an image is created thoughtfully (see: https://youtu.be/l9N6RBzZXJk for basic concepts for data visualization).

An example of an impactful data visual

For our point view, Fig. 3 is the most interesting data visual in health care published in 2016. It shows the differences between different countries in terms of life expectancy (years) and health expenditure (US dollars) per citizen on average. We can write an essay based on this data visual. In fact, the effort behind collecting data from different countries, normalization, and data processing itself can take thousands of words. It is clear from Fig. 3 that the US is spending more money on health care and achieving the lowest life expectancy compared to other countries.

One of the interesting things about the figure is the mapping of three dimensions into two dimensions. Here we have three variables, supposed to be presented with three axes: health expenditure, life expectancy, and time. The data analyst was skillful in norma-

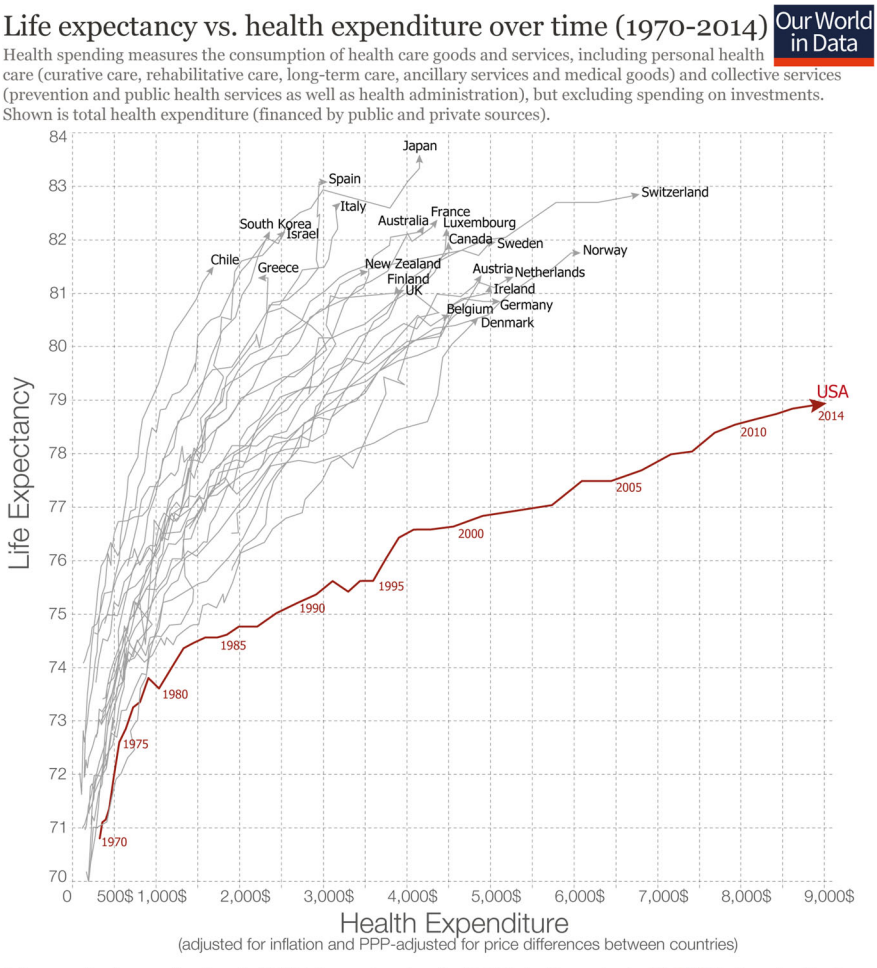

Fig. 3 An example of effective Data Visual. The data visual is represented in 2-dimensional reflecting three dimensional features (health expenditure, life expectancy, and years). It clearly shows the wastefulness of USA healthcare system compared to other countries over the same number of years

lizing every line by the period of 1970–2014, providing impactful information and showing progress over time.

Recommendations

Following the previous example, there is a need to establish guidelines for data visualization regarding what to do and what not to do. We believe that we need to evolve the publication system, and we have two recommendations: 1) create a position for a new role in our organizations and call it "data visualist," and 2) create a competition for best data visuals for knowledge translation. The role of the data visualist should be to check the main figures of a publication to ensure that the figures are truly "scientific," "knowledge translatable," and "intuitive." The competition should give feedback to scientists, especially those in health care, on how to provide robust yet efficient images that are attractive and informative.

Can we use images all the time?

The answer is no. Overusing images and not producing proper images is just adding noise. Redundant information is not useful; sometimes adding an image to text can add no value to the text. A prime example was published in 2015. Holland et al. [18] demonstrated that the addition of images within undergraduate histology exam multiple choice questions had no overall influence on item difficulty or measures of item discrimination. They concluded that the use of images in this context is statistically not useful and suggested that their inclusion within items should be based upon the principles of constructive alignment.

Conclusion

An image is worth over 30,000 words and, if crafted properly, can significantly improve the quality of disseminated research results. Appreciating the power of an image elevates the level of impact a publication will have and can create a medium that enables researchers from different disciplines to easily understand cross and interdisciplinary results and conclusions. With this kind of knowledge sharing with easy-to-understand visuals by scientists with different backgrounds, the overall research community will reap the benefits of increased results sharing, as well as new interactions and improved communication among different research communities. Moreover, an effective image can be understood by others outside the research community who may benefit from the information being shared. A well-done data visual can bring experts and non-experts together and can be understood and verbalized by scientists with different backgrounds.

Authors' contributions

M.E. designed and led the investigation. N.H., A.H., C.M., and R.W. provided suggestions and feedback. M.E. drafted the manuscript. All authors approved the final manuscript.

Funding

This research was supported by the NSERC grant RGPIN-2014-04462 and Canada Research Chairs (CRC) program.

Competing interests

The authors declare that they have no competing interests.

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Published online: 22 July 2020

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