

Chapter 5

Graphics Lies, Misleading Visuals

Reflections on the Challenges and Pitfalls of Evidence-Driven Visual Communication

Alberto Cairo

Abstract The past two decades have witnessed an increased awareness of the power of information visualization to bring attention to relevant issues and to inform audiences. However, the mirror image of that awareness, the study of how graphs, charts, maps, and diagrams can be used to deceive, has remained within the boundaries of academic circles in statistics, cartography, and computer science. Visual journalists and information graphics designers—who we will call evidence-driven visual communicators—have been mostly absent of this debate. This has led to disastrous results in many cases, as those professions are—even in an era of shrinking news media companies—the main intermediaries between the complexity of the world and citizens of democratic nations. This present essay explains the scope of the problem and proposes tweaks in educational programs to overcome it.

5.1 Introduction

Can information graphics (infographics) and visualizations¹ lie? Most designers and journalists I know would yell a rotund “yes” and rush to present us with examples of outrageously misleading charts and maps. Watchdog organizations such as Media Matters for America have recently begun collecting them (Groch-Begley and Shere 2012), and a few satirical Web sites have gained popularity criticizing them.² Needless to say, they are all great fun.

¹ I will be using the words “information graphics,” “infographics,” and “visualization” with the same meaning: Any visual representation based on graphs, charts, maps, diagrams, and pictorial illustrations designed to inform an audience, or to let that same audience explore data at will. I know that this decision will displease some scholars and practitioners, but I have my reasons. For more details (see Cairo 2012a, the Introduction in particular).

² See WTF Visualizations, URL, January 8, 2014: <http://wtfviz.net/>.

A. Cairo (✉)
University of Miami, Coral Gables, FL 33124, USA
e-mail: alberto.cairo@gmail.com

The notion that graphics can indeed lie derives from Darrell Huff's bestseller *How to Lie With Statistics* that describes the most common kinds of visual sins, such as truncating the Y-axis of graphs. Edward Tufte, always keen on contriving catchy memes, tried to coat Huff's teachings with a scientific looking varnish and invented a unit of measurement called the "Lie Factor" (Tufte 1983). He even came up with a formula to calculate it. As it happens with much of Tufte's *œuvre*, it is impossible to know whether he was writing with tongue in cheek. I assume he did:

Lie Factor = Size of effect shown in the graphic/Size of effect in data
(The closer the Lie Factor is to 1.0, the more accurate the graphic is.)

Playful quantifying efforts aside, let me take the risk of sounding platitudinous: Charts, graphs, maps, and diagrams do not lie. People who design graphics do. This is a no-brainer if we stick to a well-known definition of the word "lie" in the literature about ethics: "An intentionally deceptive message in the form of a statement" (Bok 1999). The graphic is that statement, not the agent who creates it and delivers it.

A graphic can *mislead*, though. Misleading is not the same as lying because a graphic can lead readers astray without the conscious intervention of its designer. This distinction is not a technicality. According to professional ethics codes in journalism and graphic design,³ knowing the truth and hiding it, or conveying it in a way that distorts it is simply unacceptable.

Codes of conduct are based on *a priori* rules, duties, and obligations. They are the embodiment of deontological ethics. Therefore, according to them, the intention of the agent is the key to analyzing if the actions she performs are right or wrong. On the other hand, designing a misleading graphic as a result of naive mistakes while analyzing or representing data is ethically neutral. I guess that we all can agree that lying is the worst action that any visual communication professional can perform, so lying will be the focus of the first part of this essay.

However, I find the alleged ethical distinction between lies and mistakes intriguing and worth playing with. Let's ask ourselves: Are the intentions of the designer really enough to evaluate the appropriateness of each graphic she creates? My hunch is that they aren't. Let me elaborate.

Professional codes of conduct implicitly differentiate between *truth* and *truth-telling*. In many circumstances, truth may be unattainable, fuzzy, or even unknowable, but that does not spare us of our obligation of being truthful. Someone who intends to communicate a message may not know all information needed or—more importantly for my argumentation—may not possess the skills to represent it correctly. But, if she strives to do her best, she will be acting ethically.

³ For a sample of ethics codes: see, URLs, January 8, 2013:

<http://www.journalism.org/resources/ethics-codes/>
<http://www.aiga.org/standards-professional-practice/>
<http://chrisalensula.org/the-ethics-of-visualization/>
<http://blog.visual.ly/a-code-of-ethics-for-data-visualization-professionals/>.

So far, so good. This is simpler than the stuff discussed in any Ethics 101 course. As a designer or journalist, you are likely feeling comforted at this point: “Perhaps I make mistakes sometimes but I certainly don’t lie,” you may be thinking. Allow me to distress you a bit. Don’t think just about *yourself*, the designer, when evaluating your own decisions while creating a graphic. Think of *who’s going to decode it*, too. Read the following paragraph carefully:

When we see a chart or diagram, we generally interpret its appearance as a sincere desire on the part of the author to inform. In the face of this sincerity, the misuse of graphical material is a perversion of communication, equivalent to putting up a detour sign that leads to an abyss (Wainer 2000).

Notice that Wainer does not imply that the author is trying to actively deceive you. The “misuse of graphical material” could have been completely unintentional, the same way that putting the detour sign in the wrong side of the road could be the product of sloppiness or ignorance.

Switching the focus back and forth from the designer (the encoder) to the reader (the decoder) makes the distinction between lying and misleading much blurrier, for in the world out there the consequences of both lies and mistakes are equally grave: More noise and misinformed audiences. And so, paradoxically, I feel that what was going to be a short piece to help myself reflect about lying with information graphics cannot stick to lies alone. If we agree that infographics must represent a reality—data, information—with accuracy, we must not just obsess over the conscious actions of communicators. We should also point out the responsibility we have to educate ourselves to overcome our own biases, shortcomings, and knowledge gaps. We must work hard to eliminate or, at least, to minimize ambiguity, confusion, and potential errors of interpretation in our graphics. That will be the core idea of the second part and the conclusion of this essay.

5.2 Becoming a Good Liar

It would be preposterous to pretend that a single book chapter can outline the hundreds of ways information graphics can be used to deceive. Several books (Huff 1954; Jones 2006; Monmonier 1996), among others—have been written about the topic, so I won’t repeat what they have already said. I’ll just mention Howard Wainer’s *Visual Revelations*, which explains that most graphic lies are based on three strategies:

1. Not showing much data
2. Showing the data inaccurately
3. Obfuscating the data

I have reorganized Wainer’s list, a bit for the purposes of this essay. Here is my version:

1. Hiding relevant data to highlight what benefits us
2. Displaying too much data to obscure reality

3. Using graphic forms in inappropriate ways (distorting the data)

To become a good liar you will need to learn how to use these methods, so let's illustrate them with some examples.

5.2.1 Hiding Relevant Data to Highlight What Benefits Us

Any parameter can tell us something about a population, the same way that any properly obtained statistic can tell us something about a sample from that population. Most datasets are too complex to be scrutinized directly (try to extract meaning from a table with hundreds of numbers), so we use and manipulate statistics—mean, median, standard deviation, etc.—to analyze them. However, no parameter or statistic can reveal the entire truth of a dataset. Most visual liars are very aware of this fact, and they take advantage of it.

To give you a perfect example of this strategy, stick with me through a short detour which will become relevant in Part 2 of this chapter.

In the first decade of the Twenty-first century, the marketing and P.R industry hijacked the very word “infographics” (Cairo 2012b). This word has a long and noble tradition in the news, where it is used to define visuals that display rich data, maps to locate stories, and diagrams and illustrations to explain complex processes and procedures.

News infographics are, or should be, subjected to professional standards also applied to news stories. Marketing and promotional infographics are not, as you will notice if you do a little exercise: Go to your favorite search engine and type “best infographics” or “cool infographics.” Go ahead, try it out. You will be shown piles of bad and uncool junk—and perhaps some gems; I’m willing to concede that it is possible to find shiny needles in any damp haystack, but hope weakens when one stumbles upon statements like this, common among the enthusiasts of these aberrations: “All online infographics are a form of content marketing link bait.” (Krum 2013)

To what I say: Baloney. If producing “link bait,” instead of something truthful, accurate, and deep is your goal, then you are not designing an infographic, but a poster, a flyer, or an ad. End of detour for now.

Lies in this kind of so-called “infographics” usually come in the form of cherry-picked statistics. Many of them are made of isolated figures surrounded by cutesy illustrations and colorful special effects. See the first man in Fig. 5.1, a graphic that mimics the style I’m describing. He proudly holds the average sales increase of his company over the last year: 12 %. Not bad, right?

But see what happens when we offer a more nuanced picture of what hides behind that figure (man on the right): Among the ten markets in which this company operates, five improved, but the other five shrank. Why would you hide this important bit of information from customers or investors? That was a rhetorical question, in case you did not notice. The first “infographic” is good “link bait.” The second one is true.

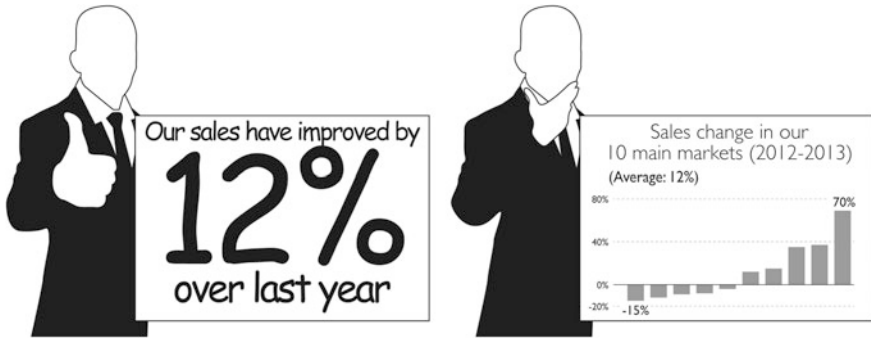


Fig. 5.1 Two versions of a fictional graphic. The first one displays just the average change, hiding the fact that the ten markets in which this company operates behaved very differently between 2012 and 2013. That reality is shown on the second version of the graphic. The average of all the values encoded in the bar graph is indeed 12 %

5.2.2 *Displaying Too Much Data to Obscure Reality*

If extreme simplification and biased data selection are reliable strategies to obfuscate data, extreme and unnecessary detail may also be effective. Compare the two maps in Fig. 5.2 (data aren't real.) Neither of them is intrinsically wrong, but the first one is much better if our goal is to give readers a quick and clear overview of the data. The second one might be appropriate if the designer wants readers to explore poor areas in detail, perhaps with the help of interactive tools, such as zooms and filters. But, if the second one is reproduced at a small size on a printed page, it will become meaningless.

5.2.3 *Using Graphic Forms in Inappropriate Ways (Distorting the Data)*

This is my favorite strategy and, by far, the most common one. Many lies in this category are grossly conspicuous, but may go unnoticed if shown quickly on a screen, or if the viewer is distracted by visual bells and whistles.

State-owned media in countries ravaged by corruption and clientelism, like Venezuela or Spain, are reliable sources of joy for visualization professors who need to gather examples for class. A more colorful version of Fig. 5.3 was used by Venezolana de Televisión after the 2013 Presidential elections, in which President Hugo Chavez's successor, Nicolás Maduro, was challenged by an emerging leader of the coalition of opposing parties, Henrique Capriles. I redrew the graphic to be able to print it in B/W, so try to imagine it in all its original tacky tricolor magnificence (use the colors of the Venezuelan flag: Pure red, blue, and yellow).

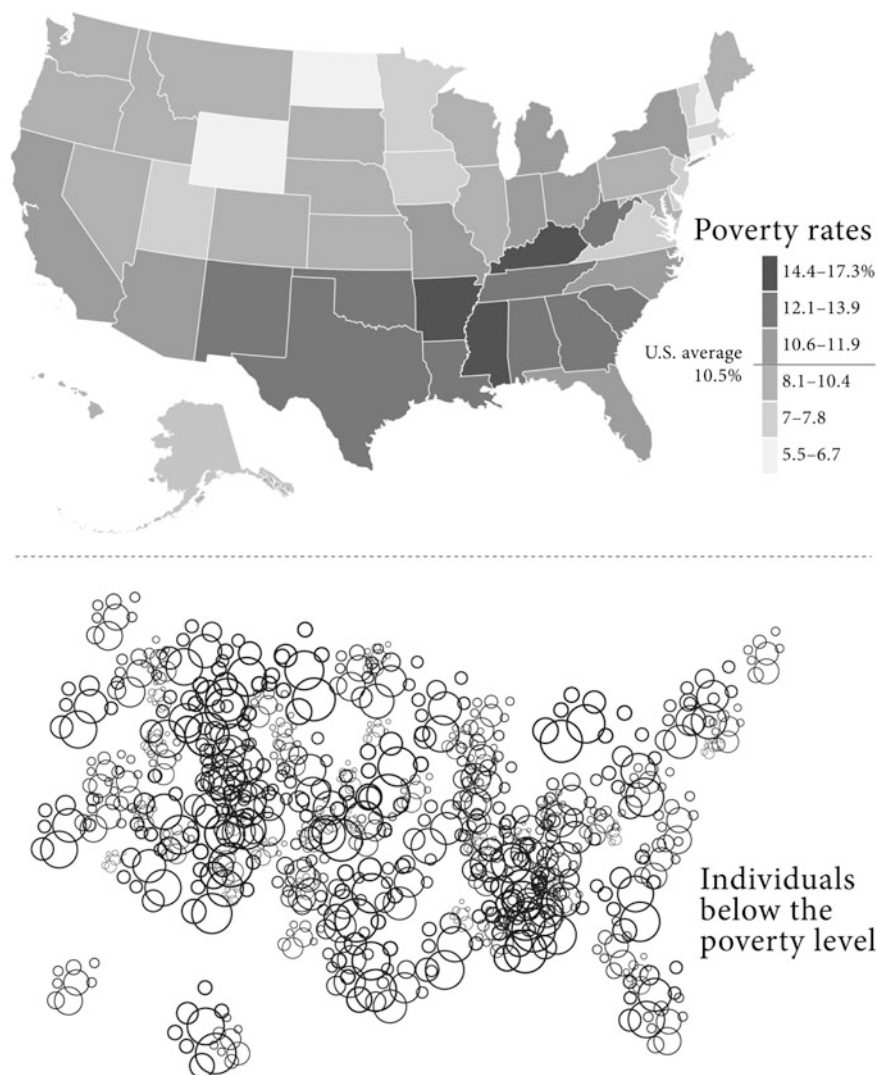


Fig. 5.2 Choropleth map and proportional symbol map. Data and locations are not real

When adding a zero-baseline, the picture becomes much more interesting—and discouraging if you are a fan of Maduro’s (Fig. 5.4). I have heard designers defend graphics like that one arguing that viewers could just read the numbers. Right but, then, what are the damn bars for? Are they just ornaments? And I could add that most people won’t have enough time to make up for the distortion if the chart stays on the TV screen for just a few seconds.

The next example is much more amusing. The original graphic was shown by TVE, the Spanish public broadcasting system, in September 2013. In this case, it’s

PRESIDENTIAL ELECTIONS, 2013

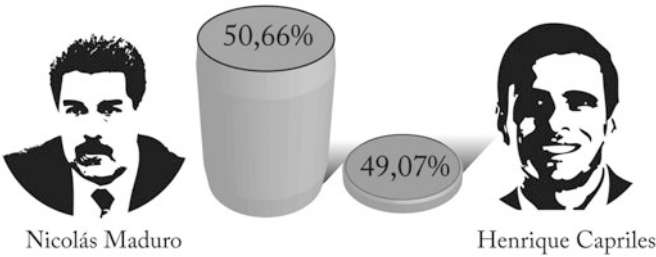


Fig. 5.3 Presidential election results in Venezuela, based on a graphic by Venezonala de Televisión. Notice the truncated Y-axis which greatly distorts the difference between the percentages of vote

PRESIDENTIAL ELECTIONS, 2013

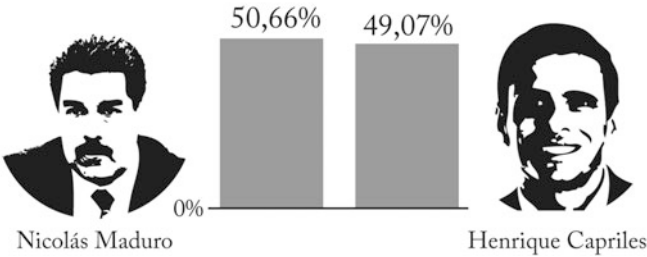


Fig. 5.4 An alternative version of the previous graphic in which a 0-baseline has been added, and the 3D effect has been removed

not just the Y-axis that was truncated; that’s almost a trivial misdemeanor here. The problem is *where the X-axis begins*. See it in Fig. 5.5 (redrawn based on the original chart):

To understand why the designer is lying, you need to know that Spain’s job market follows regular seasonal variations. A notable chunk of the country’s wealth comes from the millions of tourists who visit it every year. Thus, unemployment tends to increase during the winter and falls sharply during the summer, something that becomes clear when 12-month data are displayed (Fig. 5.6). The most news-worthy bit of information revealed by this chart is that unemployment was *higher* in August 2013 than in July 2012, something that TVE did not mention. Maybe a smart government-appointed managing editor thought that she would not be able to use the right headline if data were correctly depicted.

Another very recent example was released by Partido Popular (PP), Spain’s ruling party, in December 2013. Notice the inconsistent intervals on the horizontal axis: Until 2012, the graphic displays yearly data. Then, suddenly, it shows monthly

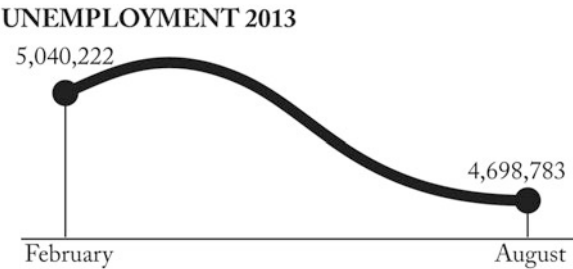


Fig. 5.5 The truncated Y-axis is not the only problem here. Based on a graph by RTVE (Spain)

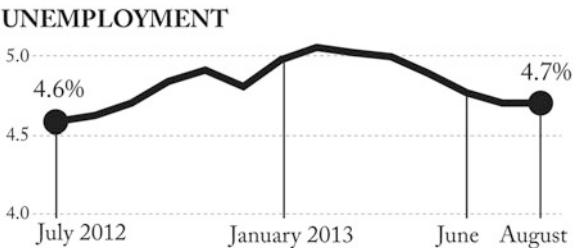


Fig. 5.6 Twelve months of unemployment rates, based on a graph by Eldiario.es. URL, January 8, 2014: <http://www.eldiario.es/>

change, but the choice of months seems arbitrary. The reason why the designer did this is not clear, but it may be related to the fact that President Mariano Rajoy approved a sharp increase in electricity prices for January 2014. Who knows? (Fig. 5.7)

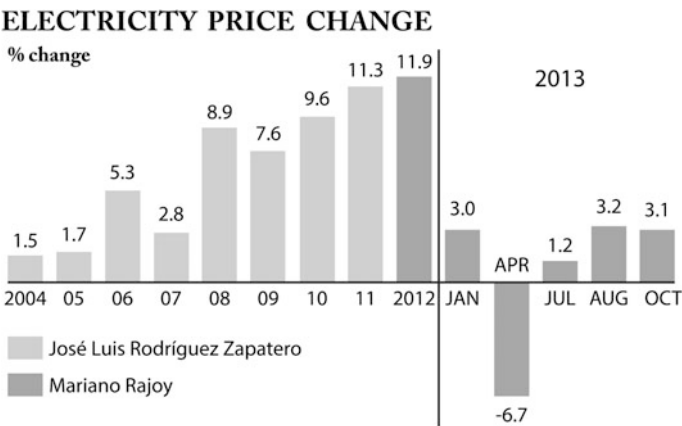


Fig. 5.7 Electricity price change, based on a graph by Spain's Partido Popular. Notice the inconsistent intervals on the X-axis

This bar graph is interesting not just because it is a good example of how sneaky politicians try to deceive citizens. It also leads us to the second part of this essay because it was uncritically reproduced by at least two of the main Spanish newspapers. The graphic passed through all the filters that journalists, designers, and the organizations they work for supposedly have to verify before they publish.

5.3 The Ignorance of Evidence-Driven Communicators

In section 1 of this essay, I explained that a single, isolated statistic can misrepresent reality. Nonetheless, allow me to cite this one, taken from a talk by Robert W. McChesney and John Nichols, authors of *The Death and Life of American Journalism* (McChesney and Nichols 2010): “The ratio of P.R professionals to journalists has climbed from 1.2-to-1 in 1980 to 4-to-1.” If that fact doesn’t worry you, it should.

It is true that many news organizations are not up to their own foundational ideals nowadays, but journalists, scientists, and information designers, people who I would propose to call evidence-driven communicators, are still the main line of defense against increasingly pervasive spin and bias in democratic societies:

“Journalism is literally being rolled over by propaganda,” said Nichols, who is a contributing writer for *The Progressive* and the associate editor of *Capital Times*, the daily newspaper in Madison, Wis. Eighty-six percent of all news stories that were printed or aired by Baltimore media in 2008 originated from what Nichols called “higher authorities,” such as public relations firms or corporate press releases. That study, which was conducted by the Pew Research Center for the People and the Press, shows that traditional journalism has been reduced to “stenography.”⁴

John Nichols

The scarcity of honest communicators is not the only problem. Many journalists and designers are not prepared to identify sophisticated propaganda. This is a point made in the last few years in books like (Goldacre 2009) and (Patterson 2013), and in numerous media criticism Web sites⁵ although it is hardly a new discussion topic (Paulos 1988). On average, journalists and information designers are not seriously trained in the scientific method, research techniques, and data. And even those few who *do use* data regularly—computer-assisted reporters, particularly those outside of the USA and the UK—usually apply just techniques based on simple descriptive statistics (Defleur 1997).

Moreover, most journalists and designers lack a basic “bullshit detector,” to use a term coined by Michael Shermer (Shermer 2011). To understand why this is problematic, remember that those professionals are responsible for holding the

⁴ See Authors Advocate Government Subsidies for Journalism, URL, January 8, 2014: http://www.fordham.edu/Campus_Resources/eNewsroom/topstories_1771.asp.

⁵ To cite just a couple of popular resources, see Lumley 2014; Malaprensa 2014.

powerful in check, and for filtering out noise so only signals will reach the public, at least in theory. If these evidence-driven communicators don't possess solid critical thinking skills, they won't be able to fight the kinds of lies outlined in Sect. 5.2.

Finally, not being ^{熟练的}versed in basic science and statistics may lead journalists and information designers to make mistakes that fall into categories that exactly match those of lies (hiding data, obfuscating data, and distorting data). The situation described in the previous paragraphs represents a huge challenge for modern democracies.

Let me ^{用例子证明、例证}exemplify my case with a story published by *Wired* magazine in August 2010. It was titled “The Web is Dead: Long Live the Internet” (Shermer 2011), and was written by Chris Anderson and Michael Wolff. The main point of the story was that the World Wide Web was in decline as a means to accessing content from the Internet: In 2010, according to the story, citizens were accessing digital content not just through their Web browsers, but mostly through smartphone apps and other services. The story was illustrated with a graphic similar to the one in Fig. 5.8, in which the decline of the WWW is striking: In 2000, it accounted for more than half of the traffic from the Internet. In 2010, it was barely 23 %.

Do you notice something fishy? Rob Beschizza, from the blog BoingBoing, did: “Without commenting on the article's argument, I nonetheless found this graph immediately suspect, because it doesn't account for the increase in internet traffic over the same period. The use of proportion of the total as the vertical axis instead of the actual total is an interesting editorial choice. You can probably guess that total use increases so rapidly that the web is not declining at all” (Anderson and Wolff 2010). It is not indeed, as Beschizza, proved with a graph in which the Y-axis corresponds to Internet traffic measured in exabytes (Fig. 5.9).

Now, ask yourself if you would call this a lie or a mistake. I don't really know what my answer would be. This could be the result of an overzealous editor trying to sell more copies of the magazine with an eye-catching and slightly controversial headline (*Wired* did receive a lot of attention thanks to this story). But were this a lie,

Internet Traffic in the U.S.

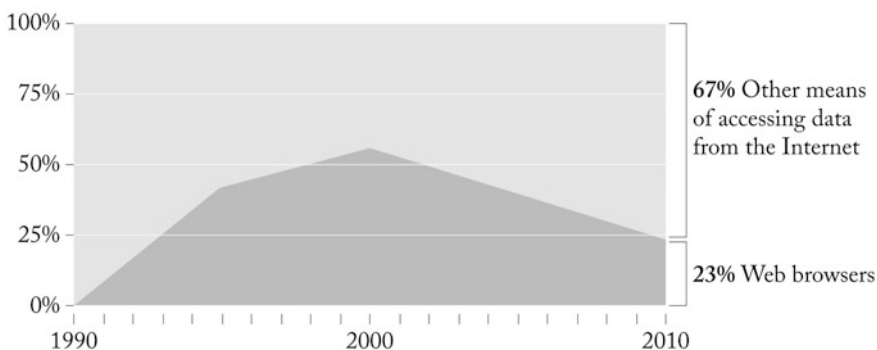


Fig. 5.8 The World Wide Web is dying, based on a graphic by *Wired* magazine

Internet Traffic in the U.S.

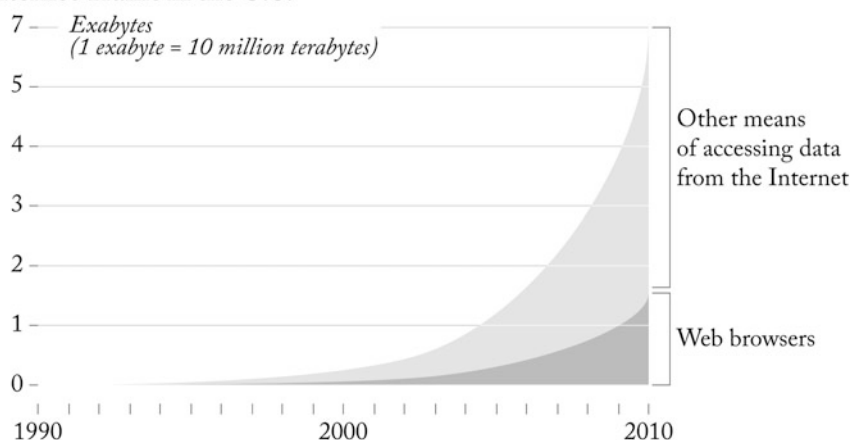


Fig. 5.9 The Web is hardly dying. Based on a graphic by Boing Boing (Beschizza 2010) BESCHIZZA Rob

a mistake, or a dubious editorial choice, does it really matter? The results are the same: Noise and a misled audience.

Another related challenge democratic societies face is that many designers of visualizations tend to yield to aesthetic preferences instead of striving for accuracy, precision, and depth first. Michael Babwahsingh, a designer based in New York City, has written:

(The) growing popularization of information design techniques reduces the practice of information design to a “look,” and may free creators of information design from any obligation to think deeply about the content and make sense of it first. What’s more, the emphasis in many websites and publications has increasingly (and maddeningly) shifted from information that is logical and meaningful to information that is beautiful. (Babwahsingh 2013)

Michael Babwahsingh

Visual appeal is undoubtedly a value worth pursuing, but not at the cost of hurting the integrity of the information, as this is one of the main sources for misleading infographics. The design of information graphics is as much an art as it is a form of engineering. There are certain guidelines and principles—I’m wary of calling them “rules”—grounded in visual perception and cognition that designers must learn and apply if they wish to communicate effectively; see (Few 2012; Kosslyn 2006; Ware 2012), among others. Unfortunately, judging by the work commonly seen in print publications, Web sites and, blogs that use infographics and data visualizations on a regular basis, many designers either are unaware of these principles or, worse, they willingly ignore them.

5.4 Conclusion: Fighting Noise with Knowledge

Visual lies are an inevitable side effect of freedom of expression. We'll never vanish them, no matter how aggressively we mock them or how thoroughly we analyze and denounce them. We will never get rid of mistakes, either. What we could do, though, is to better prepare future generations of evidence-driven visual communicators, individuals whose core goal is to inform audiences truthfully and accurately, not to sell stuff, to identify the former and avoid the latter.

Back in 1997, Jack Fuller, publisher of *The Chicago Tribune*, wrote: “We cannot accept the kind of ignorance of basic statistics that so often leads to preposterous reporting of scientific claims.” Those words belong to a chapter titled “The challenge of complexity” (Fuller 1997), and they inspired Thomas E. Patterson to claim: “Journalists cannot meet democracy’s needs unless they become ‘knowledge professionals’ who have ‘mastery not only of technique but also of content’” (Patterson 2013).

Patterson proposes to develop a new kind of journalism education. He calls it “knowledge-based journalism.” It combines deep subject-area expertise with a good understanding of how to acquire and evaluate information (research methods). I believe that the second component of Patterson’s proposal—being able to gain knowledge in a systematic manner—is more important than the first one. Therefore, to conclude this essay, I’d like to argue that information design and visual journalism programs should incorporate the following items to their curricula, as a complement to the skills and principles they have traditionally taught: 课程

1. A discussion on cognitive biases, which could be based on books such as (Chabris and Simons 2010; Kahneman 2011; Kurzban 2011).
2. An introduction to science as a method for inquiry; this would include lessons on how to read and interpret scientific claims.
3. As an extension of the previous point, an introduction to statistics which does not focus just on the mathematical minutiae—as fascinating as those can be—but on the conceptual side. It could be inspired by recent books such as Vickers (2009) and Wheelan (2012), and portions from older ones, such as Jaeger (1990, Weinberg and Shumaker 1974).
4. Foundations of computer programming.
5. Principles of cartography.
6. Visual perception and cognition applied to the design of information graphics. This part could be based on Few (2012), Kosslyn (2006), McEachren (2004, Ware (2012), etc.

Only by doing this, we will have a chance to minimize the harm that graphic lies and mistakes—being both inevitable—do to society.

References

- Anderson C, Wolff M (2010) The web is dead: long live the internet. *Wired*. http://www.wired.com/magazine/2010/08/ff_webrip/. 8 Jan 2014
- Babwahsingh M (2013) The real meaning of information design. Personal website. <http://michaelbabwahsingh.com/2013/11/29/the-real-meaning-of-information-design/>. 8 Jan 2014
- Beschizza R (2010) Is the web really dead? Boing Boing. <http://boingboing.net/2010/08/17/is-the-web-really-de.html>. 8 Jan 2014
- Bok S (1999) *Lying: moral choice in public and private life*. Vintage, New York
- Cairo A (2012a) *The functional art: an introduction to information graphics and visualization*. New Riders, Berkeley
- Cairo A (2012b) Reclaiming the word infographics. *The Functional Art*. <http://www.thefunctionalart.com/2012/12/claiming-word-infographics-back.html>. 8 Jan 2014
- Chabris C, Simons D (2010) *The invisible gorilla: how our intuitions deceive us*. HarperCollins, New York
- Cleveland WS (1993) *Visualizing data*. Hobart Press, New Jersey
- Defleur MH (1997) *Computer-assisted investigative reporting: development and methodology*. Routledge, London
- Few S (2012) *Show me the numbers: designing tables and graphs to enlighten*, 2nd edn. Analytics Press, Burlingame
- Fuller J (1997) *News values: ideas for an information age*. University of Chicago Press, Chicago
- Goldacre B (2009) *Bad science: quacks, hacks, and big pharma flacks*. Faber & Faber, London
- Groch-Begley H, Shere D (2012) A history of dishonest fox charts. *Media Matters*. <http://mediamatters.org/research/2012/10/01/a-history-of-dishonest-fox-charts/190225>. 8 Jan 2014
- Harris S (2013) *Lying*. Four Elephants Press, Vancouver
- Huff D (1954) *How to lie with statistics*. Norton, W. W. & Company, Inc., New York
- Jaeger RM (1990) *Statistics: a spectator sport*, 2nd edn. SAGE Publications Inc., Thousand Oaks
- Jones GE (2006) *How to lie with charts*, 2nd edn. BookSurge Publishing, Charleston
- Kahneman D (2011) *Thinking, fast and slow*. Farrar, Straus and Giroux, New York
- Kosslyn SM (2006) *Graph design for the eye and mind*. Oxford University Press, United Kingdom
- Krum R (2013) Infographics and relevance: 3 tips to improve SEO results. *Vision interactive*. <http://www.vizioninteractive.com/blog/infographics-tips-improve-seo/>. 8 Jan 2014
- Kurzban R (2011) *Why everyone (else) is a hypocrite: evolution and the modular mind*. Princeton University Press, New Jersey
- Lumley T (2014) NZ electoral visualizations. *StatsChat*. <http://www.statschat.org.nz/>. 8 Jan 2014
- McEachren AM (2004) *How maps work: representation, visualization, and design*. The Guilford Press, New York
- Malaprensa (2014). <http://www.malaprensa.com>. 8 Jan 2014 (in Spanish)
- McChesney RW, Nichols J (2010) *The death and life of American journalism: the media revolution that will begin the world again*. Nation Books, New York
- Monmonier MS (1996) *How to lie with maps*, 2nd edn. University of Chicago Press, Chicago
- Patterson T (2013) *Informing the news: the need for knowledge-based journalism*. Vintage, New York
- Paulos JA (1988) *Innumeracy: mathematical illiteracy and its consequences*, 5th edn. Hill and Wang, New York
- Shermer M (2011) *The believing brain: from ghosts and gods to politics and conspiracies*. Times Books, London

- Tufte EE (1983) The visual display of quantitative information. Graphics Press, Cheshire, p 57
- Vickers AJ (2009) What is a p-value anyway? 34 stories to help you actually understand statistics. Pearson, London
- Wainer H (2000) Visual revelations: graphical tales of fate and deception from Napoleon Bonaparte to Ross Perot. Psychology Press, London
- Wheelan C (2012) Naked statistics: stripping the dread from the data. W. W. Norton & Company, New York
- Ware C (2012) Information visualization: perception for design, 3rd edn. Morgan Kaufmann, Burlington
- Weinberg GM, Shumaker JA (1974) Statistics: an intuitive approach, 3rd edn. Brooks/Cole Publishing, Three Lak

Author Biography

Alberto Cairo (Journalist, Information Designer and Researcher) teaches information graphics and visualization at the School of Communication of the University of Miami since January 2012. He is the author of 'The Functional Art: An Introduction to Information Graphics and Visualization' (Peachpit Press, 2012).

He has been a professor at the University of North Carolina-Chapel Hill, and director of infographics at El Mundo (Spain) and Época magazine (Brazil). In the past decade has consulted for media organizations and organized training programs in more than twenty countries.

For more information and contact:

<http://www.thefunctionalart.com>.

<https://twitter.com/albertocairo>.