

Data Visualisation Literacy

– Learning to See

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ABSTRACT

In recent years, there has been increased discourse about data visualisation literacy. Literacy is defined as the ability to read and write. Applied to data visualisation, this means possessing the literacy to know how to comprehend visualisations (read) as well as being able to create them (write). Building on experiences collaborating with researchers on the ‘Seeing Data’ visualisation literacy study (seeingdata.org), combined with a decade of experience teaching data visualisation in commercial and academic settings, this article explores the mechanics of how we make sense of visualisations as viewers. The proposed step-by-step breakdown of the process for making sense of a visualisation provides a strategy for extracting the maximum understanding.

Classification JEL: MO, Z0

KEYWORDS

Data Visualisation, Visualisation Literacy, Infographics, Information Design, Charts, Data Literacy.

RESUMEN

En los últimos años, ha aumentado el discurso sobre la alfabetización en visualización de datos. La alfabetización se define como la capacidad de leer y escribir. Aplicado a la visualización de datos, esto significa poseer la alfabetización para saber cómo comprender visualizaciones (leer) así como poder crearlas (escribir). Sobre la base de las experiencias de colaboración con investigadores en el estudio de alfabetización en visualización, *Seeing Data*¹ (lookingdata.org), combinado con una década de experiencia en la enseñanza de la visualización de datos en entornos empresariales y académicos, este trabajo explora la mecánica de cómo le damos sentido a las visualizaciones como espectadores. El desglose propuesto paso a paso del proceso para dar sentido a una visualización proporciona una estrategia para extraer la máxima comprensión.

Clasificación JEL: MO, Z0

PALABRAS CLAVE

Visualización de datos, Alfabetización en visualización, Infografías, Diseño de información, Gráficos, Alfabetización en datos.

1. Introduction: Making sense of a data visualisation

Historically, a greater degree of attention has been paid to enabling others to create visualisations, such is the appetite of people to develop this skillset. However, there is growing recognition of the importance of educating people in how to become sophisticated consumers of visualisations. To be a good writer, you also need to be a good reader.

When we encounter a visualisation, we rarely think about how we go about this seemingly natural act. We just look at the charts and we read them and learn from them, what else is there to consider?

The point is we are all viewers. We encounter visual displays of information across all aspects of our daily lives. We cannot escape them in the workplace, in our studies, nor in the media. For people whose role it is to create visualisations, even if they spend most of their time doing that, they still need to possess high-level critical reasoning skills as a viewer to do their job well. Yet few of us will have been taught how to go about effectively consuming charts and graphics. We might have received some instruction about how to read charts and histograms, maybe even a scatter plot, if we studied maths or the sciences at school. Otherwise, we get by on instinct and common sense, at best.

But ‘getting by’ is not really good enough, is it? Even if, through exposure and repetition, we hope gradually to become more familiar with the most common approaches to visualising data, this does not sufficiently equip us with the breadth and range of visualisation literacy that is demanded by the variety of creative techniques employed today.

In fact, to be an active member of modern society, politically and culturally, knowing how to make sense of visual forms of data is a crucial capability. But what is the process for effectively and efficiently drawing understanding from a data visualisation?

What follows is a step-by-step breakdown of the components of effectively working through the process of comprehending a visualisation as a viewer. This demonstration will provide you with a strategy for approaching any visualisation you encounter, giving you the best chance of understanding how to consume it and ensuring you gain the benefit from being able to consume it.

To start I will outline the instinctive thoughts and judgements you will need to make before you begin working with a visualisation. I will then separate the different features of a visualisation, first by considering the common components that typically sit outside the chart and then some pointers for how to go about making sense what is presented inside the chart.

A. Before You Begin

Prior to getting into the details of the visualisation’s contents, there are quite instinctive thoughts that will cross your mind as you prepare to engage with a data visualisation work. These will be decisive in influencing your willingness to engage and how much effort you are prepared to invest.

Setting: Where are you when you encounter this work? What are the circumstances you find yourself in? Think about whether the setting is conducive to consuming a visualisation at that moment in time. Are you under

any pressure of time? Are you on a bumpy train trying to read this on your smartphone? Are you far away from a screen? Are there any environmental or situational impairments to your viewing experience?

The format: Considering the proposition offered by the visualisation is about determining how big a task you have ahead. Is the format of the work printed or digital? Does this influence your potential appetite for engagement? Is it a static or dynamic piece, and what does this present in terms of consuming task size?

- If it's a static graphic, how large and varied is the content –is it a dense display with lots of charts and text, or quite a small and compact one? Does the sequence of content appear logical?
- If it's dynamic, how much potential interactivity does there appear to be? Are there many buttons, menus, options, etc.? Where do the interactive events take you? Are there multiple tabs, pages or layers beneath this initial page? If the project layout exceeds the dimensions of your screen display, how much more scrolling or how many different pages will you have to look through to see the whole?

Initial scan: It is inevitable that your eyes will be instinctively drawn to certain prominent features. This might be the title or even the chart itself. You may be drawn to a strikingly large bar or a sudden upward rise on a line chart. You might see a headline caption that captures your attention or maybe some striking photo imagery. It is hard to fight our natural instincts, so don't. Allow yourself a brief glance at the things you feel compelled to look at –these are likely the same things the visualiser is probably hoping you are drawn to. Quickly scanning the whole piece, just for an initial period of time, gives you a sense of orientation about what is in store.

Visual appeal: You will be making a number of rapid judgements to determine whether you are sufficiently engaged with the work you are about to consume. This is an emotional consideration about whether the look and feel of the visualisation –its 'form'– charms you aesthetically and motivates you to want to spend time with it. This can be a powerful instinct, but equally influential when absent.

Subject relevance: Another instinctive judgment is whether the subject matter interests you. You might have decided you are 'on board' with regard to the appeal you have towards the aesthetics, but the next key junction concerns if the topic is interesting or relevant to you. Is the visualisation

going to facilitate useful understanding that enlightens you about a topic which means something to you? Not everyone, at the time of consuming a visualisation, has the inclination to engage with it, especially if they have no interest in a subject or if it has no immediate relevance to their needs.

If you respond positively to these first few considerations, you will likely be intent on continuing to work through the task of making sense of the visualisation. Even if you are just positive about one or two of these factors (maybe the appeal of the form or the subject matter) that may be enough to convince you to persevere, despite the implied indifference about the other matters. If the setting is suboptimal, if you have a negative visceral reaction to how the work looks, and if you have no interest in the subject matter, then your willingness to continue may be abandoned before you even really started.

B. Outside the Chart

Before our attention gets too caught up in making sense of any chart displays, you need to develop the habit to carefully assess the features of assistance provided by the creator. These will be helpful to you to prepare your understanding of the work. Not all data visualisations will always need to include all these features. There may be a good reason for this, depending on the context, but it may also be that missing features have simply been neglected by the creator. That would point to flawed design. In such cases the viewer is not being given sufficient assistance by the creator.

Headings: What is this work specifically about? Although you have already determined the potential relevance of this subject matter to you, by closely examining the visualisations titles and headings, you should gain a little more insight into prospective contents of the visualisation. You might learn about a key finding that the visualisation will reveal, or it may offer a question to which the visualisation will offer an answer. Sub-headings will usually offer more descriptive detail about the contents of the work.

Introduction: Some visualisation projects will be relatively self-explanatory, depending on the familiarity of the audience with the subject matter, but others may need additional set-up information. Including introductory text will help ‘set the scene’, providing some further background about the project. This may be presented alongside a heading or may be provided dynamically via a ‘more info’ interactive option.

Data source: Any trustworthy data visualisation should include clear information to explain the source of the data. Typically, these details will be

located in an introduction, as a footnote beneath a chart or at the bottom of a page. For creators, it is very important to provide information about the origin of the data and when no such information is provided, that legitimately lowers trust.

Data handling: It is also important to explain how data has been gathered and what methods have been employed to prepare the data. This is about transparency. Provide details about any criteria applied to include or exclude data items. Describe the rationale behind any crucial assumptions, calculations or transformations that have been undertaken.

C. Inside the Chart

Now you commence the process of deriving understanding from the chart. Regardless of how the data is represented, the phases we go through are common to all visualisations: perceiving, interpreting and comprehending (Figure 1).

These are not just synonyms for the same word, rather they convey distinctions in cognitive focus even if, in reality, the phases might feel rather indiscernible.

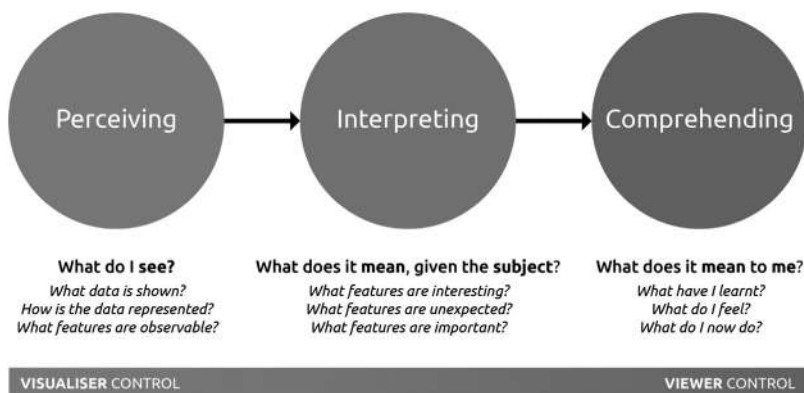


Figure 1. The three phases of understanding as a viewer makes sense of a visualisation.

Perceiving: The first phase is perceiving, and this requires the viewer to consider ‘what do I see?’. The task is to decode how the data is represented to form initial observations about the main features of the displayed data:

- What chart is being used and what does it show? How is the data represented: what association is there between the different marks and attributes being used? The process of perceiving different charts will vary depending on which type is being used
- Where axis scales are used, what range of values are displayed?
- What are the main observations taken from the display?
 - What features -shapes, patterns, differences or connections –are observable?
 - Where are the largest, mid-sized and smallest values? (known as ‘stepped magnitude’ judgements)
 - Where is the most and the least? Where is the average or normal? (‘global comparison’ judgements)

Interpreting: The second phase of understanding, translates the initial observations into quantitative and/or qualitative meaning. This involves assimilating what you’ve observed against the context of what you know about the specific topic of analysis being represented. In other words, given the subject, and given what you’ve seen, what does it all mean?

- What features -shapes, patterns, differences or connections –are interesting?
- What features are expected or unexpected?
- What features are important given the subject?

A viewer’s ability to perform rational interpretation will be significantly determined by factors external to the visualisation itself. To fulfil the perceiving of a chart, viewers need the context of scale; to fulfil the interpreting of a chart, viewers need the context of subject, so the knowledge already possessed about the subject and their capacity add to this knowledge is fundamental.

Any deficit in a viewer’s connection to a subject will fundamentally impede progress towards performing interpretation. Additionally, this may heighten the risk of the viewer drawing spurious or unsupported interpretations from a visual display. In situations where a potential viewer might not possess sufficient knowledge of a subject it will require the visualiser to assist in bridging the gap between observation and meaning. This can be achieved through simple design elements like the provision of captions, inclusion of call-out headlines, or perhaps the astute use of colour to create emphasis, for example.

Comprehending: The final phase of understanding is comprehending, which is the consequence of the viewer’s experience, who now considers ‘what do these interpretations means to me?’

- What has been learnt? Has it reinforced or challenged existing knowledge? Has it enlightened with new knowledge?
- What feelings have been stirred? Has the experience impacted the viewer emotionally?
- What does one do with this understanding? Is it just knowledge acquired or something to inspire action, such as making a decision or motivating a change in behaviour?

In accomplishing the comprehending phase of understanding, this represents the culmination of the task of making sense of, and from, a visualisation.

2. Becoming a more sophisticated consumer

As children we develop the ability to read numbers and words. This is formed through being taught how to make associations between numeric digits and the numeric values they represent, as well as alphabetical characters and the letters and words they form. From there, we begin to understand sentences and, eventually, as we build up a broader vocabulary, we acquire the literacy of language. This is all a big effort. We are not born knowing languages, rather we are born with the capacity to learn languages.

Beyond written language, something as simple and singular as the Wi-Fi symbol, for example, is now a universally recognised form of visual language. However, the meaning of this symbol would have no impact on people living even as recent as the 1990s: it is a symbol of its time. We have learnt to recognise its representation and understand its meaning in this contemporary era where access to the internet is so fundamental.

Across all aspects of our lives, things that once seemed complicated and inaccessible can become automatic competencies, such as driving a car, using a keyboard, or cooking a meal. Some things are easier to attain than others, but if we put in the effort and receive necessary assistance, we can learn. Our capacity is phenomenal.

Another context. I often think back to growing up in the 1980s and my first home computer, which was the Commodore 64. In the UK, one of the most popular computer games of the time was Daley Thompson's Decathlon. Of particularly nostalgic fame was the brutally simple operation of maniacally waggling the joystick arm left and right to control the running events, alongside a button which came into use when there were hurdles to jump over. Consider the simplicity and immediately learnable control configuration of that game. Contrast it with the huge variety of control options and combinations found with modern video games on the Xbox or PlayStation.

Kids today are adept at quickly mastering these games. They have utilised their capacity to learn through reading instructions and the value of repeated practice. They try things, make mistakes and then experience success.

Many data visualisations will be intended for and designed to fulfil relatively quick viewing, offering immediately clear messages that can be easily comprehended. These works are the equivalent of the C64 joystick controls. Conversely, there will be occasions when, as a visualisation viewer, you encounter analysis that is more complex in nature, perhaps about a technical topic or displaying multiple unusual chart types. In these situations, there is a greater demand placed on your capacity and willingness to learn. To overcome the obstacles created by your deficit in knowledge about a subject and your lack of familiarity with the visual methods used takes effort and needs motivation. It also needs the creator to provide the necessary assistance to help reduce the obstacles. This is the equivalent prospect of mastering the console game controls. If you don't have the capacity to extract as much understanding from the viewing experience as possible and doing so as efficiently as possible, you are potentially missing out.

The demands of learning anything new or seemingly complicated can trigger a lazy reluctance. It is human nature to prefer to avoid having to expend effort thinking deeply and rationally.

In the influential book 'Thinking Fast and Slow', about judgment and decision-making, author Daniel Kahneman, the esteemed psychologist and economist, proposes two models of thought that control our thinking activities. He calls these System 1 and System 2: the former is responsible for our instinctive, intuitive and metaphorical thoughts; the latter is much more ponderous, much slower, and requiring of more mental effort when being called upon. For example, you are acutely aware of thinking when trying to run a mathematical calculation through your mind. That is System 2 at work. When there is a need for System 2 thinking our brain instinctively tries to avoid whatever mental effort that activity will entail. We get lazy and resort to shortcut solutions or decisions based on intuition. Enter System 1. System 1 thinking essentially persuades System 2 to sit back and let it run things.

Of course, there are other factors that will affect our capacity to learn, such as having the time, receiving assistance or tuition, and recognising the incentive. These are all enablers and therefore their absence can create obstacles to learning. Without assistance from the visualiser, viewers are left to fend for themselves. The role of this book has primarily been to try to raise the standard of the design choices that visualisers make when creating visualisations. Visualisers do not want to obstruct viewers from being able to read, interpret and comprehend. If work is riddled with design errors and misjudgements, then viewers are naturally going to be disadvantaged.

Many of the visualisations you will encounter may be unfamiliar the first time you see them. Everything is new once. Give yourself the chance to learn. The confidence you have in being able to read different types of charts will develop through practice and repeated exposure. It will be slow and deliberate at first, probably noticeably effortful, but then, over time, as the familiarity increases and the experiential benefits kick in, perceiving these different types of representations will become quite effortless and automatic. The laborious nature of System 2 thinking will be exchanged by the more rapid form of System 1 thinking. Your literacy will increase.

Effective visualisation requires the visualiser and viewer to operate in harmony, otherwise the possibility of facilitating understanding is compromised. Beyond the mechanics of perceiving a visualisation, there are softer ‘attitudinal’ differences you can make to give yourself even more of a chance of gaining understanding. This is about modifying your mindset to be more critically appreciative of the challenges faced by the visualiser responsible for producing the work as well as its intended purpose. It is about showing empathy in your critical evaluation which will markedly help you become an increasingly sophisticated consumer:

Appreciation of context: When consuming a visualisation try to imagine some of the circumstances and constraints that might have influenced the visualiser’s decisions:

- You might not find the subject matter interesting, but other people might. You have the right not to read or interact with a visualisation that has no relevance to you. If it should have relevance, then that’s when there may be some problems!
- If you are struggling to understand a visualisation it could be that the project was aimed more at specialists, people with specific domain knowledge. Your struggles are possibly not a reflection of an ineffective visualisation or any deficit in your expected knowledge –it just was not intended for you.
- If the size of the text is frustratingly tiny on your screen, maybe it was intended primarily for printing as a poster and would have been the right size if consumed in its native format?
- When criticising a work, spare a thought for what could have been done differently. How would you imagine an alternative way to represent the data? What other design solutions would you have tried? Sometimes what is created is a reflection of crippling constraints and might more closely resemble the least-worst solution than the best.

Appreciation of intent: Sometimes a visualiser only aims to offer a sense of the big picture –the big values, the medium and the small ones. Just because we cannot instantly read precise values from a chart it is important to avoid getting frustrated. Our default state as viewers is often to want every detail available. Sometimes, we just need to accept the idea that a gist of the hierarchy of values is of more worth than the precise decimal point precision of specific values. It may be that it was not feasible to use a chart that would deliver such detailed reading of the data– many charts simply cannot fulfil this. We might not even realise that we are just a mouseover or click away from bringing up the details we desire.

False consciousness: Do you really like the things you like? Sometimes we can be too quick to offer a ‘wow’ or a ‘how cool is that?’ summary judgement before even consuming the visualisation properly. It is quite natural to be charmed by a superficial surface appeal (occasionally, dare I say it, following the crowd?). Ask yourself if it is the subject, the design or the data you like? Could any portrayal of that compelling data have arrived at an equally compelling presentation of that content?

Curiosities answered, curiosities not answered: Just because the curiosity you had about a subject is not answerable does not make the visualisation a bad one. Statements like ‘This is great, but I wish they’d shown it by year ...’ are valid because they express your own curiosity, to which you are entirely entitled. However, a visualiser can only serve up responses to a limited number of different angles of analysis in one project. The things you wanted to know about, which might be missing, may simply have not been possible to include or were deemed less interesting than the information provided. If you are thinking ‘this would have been better on a map’, maybe there was no access to spatial data? Or maybe the geographical details were too vague or inaccurate to generate sufficient confidence to use them?

3. Conclusion

Visualisation literacy is a shared responsibility between visualiser and viewer. A visualiser must, of course, seek to make the visualisation they create as understandable as possible, and provide necessary assistance to help the viewer perceive, interpret and comprehend. However, the visualiser can only ultimately influence the facilitation of understanding, they cannot control it. Ultimate control is determined by the willingness, the motivation and, crucially, the capability of the viewer to possess the necessary literacy to know how to maximise what understanding they derive from

the experience. This article has proposed a strategy to help viewers with an efficient and effective approach. With greater exposure than ever before to visual displays of information, there is good reason for us all to heighten our confidence navigating through a data-rich world.

References

Many concepts for this article emerged from the ‘Seeing Data’ visualisation literacy study (seeingdata.org) on which I collaborated with researchers from University of Leeds and University of Sheffield.

- CLEVELAND, W.S., and MCGILL, R.M. (1984) Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods’ *Journal of American Statistical Association*, vol. 79, no. 387, pp. 531-54.
- BERTIN, J. (2011) *Semiology of Graphics: Diagrams, Networks, Maps*. Redlands, CA: ESRI Press.
- KAHNEMAN, D. (2011) *Thinking Fast and Slow*. New York: Farrar, Straus & Giroux.
- KIRK, A. (2019) *Data Visualisation: A Handbook for Data Driven Design* (2nd Edition). London: Sage.
- LEIBOVICH, T., KATZIN, N., HAREL & HENIK, A (2017) ‘From “sense of number” to “sense of magnitude”’: The role of continuous magnitudes in numerical cognition’. *Behavioral and Brain Sciences*, pp. 1-62.
- REICHENSTEIN, O. (2013) *Information Architects*. <https://ia.net/know-how/learning-to-see>.
- TUKEY, J.w. (1980) We need Both Exploratory and Confirmatory, *American Statistics*, vol. 34, no.1 pp.23-5.



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