Infographics and Communicating Complex Information

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Abstract. With the growing use of infographics to communicate complex information, we must specifically look at how people read and understand them. Complex information depends on helping people build relationships and connect the information to the current situation. Infographics are not art displays, but are tools to communicate information. Unless we understand how people comprehend information and how those mental transformations occur when they read the content, we cannot effectively design an infographic for complex information. People come to an infographic for a purpose and with a goal, both of which require the infographics to communication complex information. A good infographic must maintain the complexity of the information while lowering the barriers to its comprehension.

Keywords: Complex information · Infographics · Communication

1 Introduction

Infographics provide a means of using graphic design to visualize content that has long existed in other forms. One of their advantages is that complex information can often be better communicated with a visual-heavy combination of text and visuals than with text, perhaps supported by a few visuals. While not appropriate or useful for all types of content, infographics provide context by using visuals to show relationships in data, anatomy, hierarchy, chronology, and geography. Communicating relationships are at the heart of communicating complex information [1] and infographics excel at communicating that aspect. Increasingly, even high content websites are designing layouts that incorporate infographics as a fundamental method of communicating information.

The loose definition of infographic used here is: *An infographic is a web-based image that takes a large amount of information in text or numerical form and condenses it into a combination of images and text with a goal of making the information presentable and digestible to an audience* [4].

Missing from much of the infographic discussion are good guidelines on how to craft the content into an integrated visual, with text and graphics supporting each other. With the growing use of infographics to communicate complex information, we must specifically look at how people read and understand them. We need to explore the connections between communicating complex information and designing highly-visual representations of that information.

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Prior research has looked at design of complex information in both online and print. This paper strives to merge these two research threads to help develop a clearer understanding of when and how to develop infographics. It will examine:

- Different levels of comprehension of infographics
- Tease out factors that impact comprehension
- Relate the factors to existing design guidelines and consider possible changes

1.1 Categories of Infographics

The author's prior research [4] found infographics can be divided into four categories: bullet list equivalent, snapshot with graphic needs, flat information with graphic needs, and information flow/process (Fig. 1). Of these four categories, only the last two (and, primarily, the last) are applicable to complex information presentation.

The first two categories, and especially the first one, typically fail to have any clearly defined audience. Instead, the audience could be considered "anyone interested in xxx." An audience definition such as this is much too vague to be useful for a designer and could be better seen as a rationalization for the audience for a work created without any specific audience at all. Both fail to support communicating complex information and will not be considered further in this paper.

1.2 Complex Information Cannot be Reshaped as Simple Information

The information to be communicated by a high-quality infographic qualifies as complex information, but typical infographic design reshapes it into simple information [1]. A common example is essentially all of the "Six points for…" articles and infographics. That transformation removes the information relationships and divides up the content, and, as a result, by removing relationships, seriously limits the comprehension a person can gain of the overall situation [2, 3].

Infographics as they're typically produced reduce problems to statistics—numbers and percentages that can't possibly capture the profound impact on the real world. The relationships between the numbers go away and only the numbers, as single factoids, remain. It is easy to create a diagram for factoid numbers and statistics; connecting those factoids into a complex relationship web is difficult. The transformation to a simple problem often results from an over-focus on visual presentation. Numbers are very visual, but the relationships are more than arrows between numbers; they require text and *context*. Infographics that privilege the graphical aspects—a view that could be summed up as "it's visual, it's graphical, and therefore it is better"—fail because they didn't focus on communicating information.

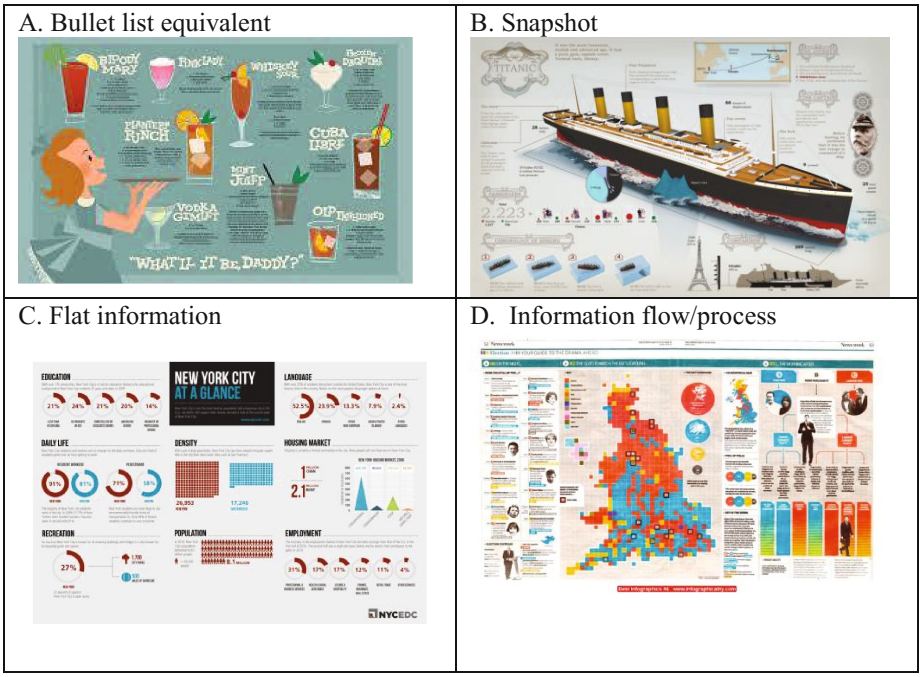


Fig. 1. Four categories of infographics. A. Bullet list. The entire infographic is just a list with graphical elements added. B. Snapshot. Content that lacks a sequence for reading, is static, and typically does not need to be compared. C. Flat information with graphic needs. Content that lacks a reading sequence, but supports comparing relationships and different data. D. Content that shows some sort of flow or process and has a defined reading sequence.

2 Information Comprehension Research

Many designers seem to assume if they place content before a reader, the reader will figure it out and gain the required knowledge. An end result of this over-privileging of visuals is a decrease in the comprehension of the information; an exactly opposite effect of why the infographic was created in the first place. Sound research, interesting information, and insightful analysis make great content. The format is far less relevant. The design team's first question should never be "how do we make an infographics?" but should be "what is the best presentation/format to communicate this content?"

A design team's ability to judge how well people will comprehend the material varies, but it's the comprehension level that matters for complex information. Once the design requirements move past "look pretty," how well people comprehend the information and their ability to pull the most salient points from the design becomes paramount.

The research literature supports that comprehension consists of the construction of multi-level representations of texts ("texts" is used here in a highly generic sense that includes infographics, web pages, etc. and not just printed documents). Moving beyond

that basic level of agreement proves problematical. Comprehension has traditionally been one of the elusive, controversial constructs in cognitive science [i.e., 19, 32]. It is perhaps impossible to propose a definition that is complete and that would be accepted across all disciplines. Text comprehension can be considered reading while trying to maintain semantic coherence—"fitting new information into existing knowledge structures" [24, p. 840, 33]. Kintsch's [19] construction-integration model has replaced a passive process of collecting isolated facts with an active comprehension process where the reader interacts with the text to build meaning.

Research into comprehension has found a wide range of issues that affect how well a person comprehends the content. Design teams need to consider these factors in the early design phases of creating an infographic.

- Comprehension improves when the reader has adequate background knowledge to assimilate the text.
- Any content written in unfamiliar terms gets ignored as irrelevant regardless of its importance. If people can't understand the content on first reading, rather than trying to figure it out, they simply drop it from their information evaluation.
- As the amount of information increases, people increasingly ignore information that conflicts with existing knowledge or with building the relationships they want to see or expect to see [14].
- Information salience influences the order in which a person considers information and the relative importance they assign to it. With poor information salience, the reader can easily ignore important text. One-size-fits-all solutions or designs without a clear audience tend to have very poor information salience.
- Information a person does not see, whether in a different document or scrolled off the screen, receives reduced salience compared to the currently viewed information.
- People process information based on the presentation. Side-by-side comparisons yield different results than sequential comparisons [16]. This result, along with information salience issues, strongly affects comprehension when the infographic requires scrolling.
- When people read a text, they try to form the most globally coherent mental representation possible [15] unless the text is very poorly composed, which causes them to quit trying to make connections.
- People attempt to mentally shape a text into a globally coherent whole. If the text lacks sufficient cues, they will settle for local coherence. When this happens, people end up seeing the text as a collection of disconnected statements.

3 Graphical Research for Information Comprehension

Graphics in technical material rarely exist without text and an integrated presentation does improve comprehension [6]. However, there is a poor understanding of how graphics actually work cognitively and the area is rife with un-researched assumptions and fallacies [27]. Assumptions and fallacies that seem to appear on every how-to list for infographic design.

People need to evaluate and synthesize the infographic. Complex information is more than a collection of factoids, but is a collection of relationships that must be connected to a real-world situation. The information salience influences how people perceive graphics and associate information.

- By their nature, infographics tend to be visually noisy. Since visual complexity could distract viewers from the intended message, they may be defeating their intended purpose [18].
- People think they use more information than they actually do when evaluating the content.
- Salience factors must be considered because people tend to underestimate the weight placed on important cues and overestimate weight placed on unimportant cues [5]. Overly prominent, but of lesser importance, graphical information can skew people's decision making.
- People say they prefer 3D graphs and a 3D definitely has a better "cool factor," but 2D graphs are read more accurately [13] and are rated as better at conveying information than 3D [21].
- People assume a linear relationship. If the data is non-linear this will cause widely wrong predictions of future values. In particular, they significantly underestimate exponential growth [31].
- Upward and downward trends get interpreted differently. People overestimate downward trends and underestimate upward trends and they are poorer at estimating downward trends than upward trends [26].

People expect to see trends in data; most graphs which they see contain some sort of trend [26]. However, the human visual system is so focused on seeing trends that it will find trends in random data. Or will find trends about a specific item of interest even if the data does not reflect it. The deep cognitive processes that lead to implicit trend identification also make it easy to mislead. Huff and Geis [17] show many examples of how to distort information. Tufte [29] gives multiple examples of what he calls 'chartjunk,' essentially everything on a graphic that does not directly support the main message. Kosslyn [20] points out how the rapid mental processing of a graphic is also its shortcoming. People form an initial impression very rapidly and then have a hard time shifting from that impression; generally, they do not unless forced to do so by the situation. As a result, it is easy to design infographics which give a desired initial impression which leave out or distort information. As a result, they fail to stand up to deeper scrutiny.

An important, but often neglected, aspect of much information design is that people need be able to accurately remember the information. A person looks at an infographic for a short time, but to be useful they need to retain that information in a form that will be useful. Comprehension is not finding a datum while looking at an infographic, but having the content in a mental representation that can be used when the infographic isn't available [25]. Improper information salience or the use of highly colorful decorative graphics can shift the remembered details from the critical content to a pretty picture.

3.1 Research on Understanding Complex Information

A substantial part of the "how-to" infographic literature confuses comprehension with perception. The difference between comprehension and perception is that perception only uses/measures inputs from the environment, while comprehension takes that perception and combines it with previous knowledge so that it logically fits the situation. Perception measures if the words or design on a page are seen (did the red color make people see this factoid better?). Comprehension, on the other hand, measures if those words or designs are put into a meaningful context. The problem is that a focus on perception means getting readers to look at something, which is easy to measure and easy to design for. But a focus on comprehension means ensuring the readers can use the information.

When people read a complex infographic, they attempt to construct a mental representation that addresses their goals and is coherent at both local and global levels [7, 30] and from that coherent view they build relationships that connect to their situation [33]. Too many infographics lack that coherence because they deal with information factoids or disconnected visuals [15].

A substantial part of forming the coherent mental representation comes from prior knowledge [24]. Prior knowledge helps people build the relationships between different pieces of information that are vital to comprehension by providing the knowledge to fill in gaps [3, 23]. For example, people with better baseball knowledge will comprehend an infographic about baseball better than people with low baseball knowledge. Without some relevant knowledge, people mentally process the text as a set of disjointed, isolated information elements and they often do not see how those information elements relate to each other [12].

People's reading ability have a significant effect on comprehending a text since it influences how well they can parse the sentences and build up a meaningful mental structure on which to integrate their prior knowledge. Reading ability has been shown to be a stronger predictor of text comprehension than prior knowledge [11]. Of course, better readers better comprehend text—because that is the underlying definition of reading skill. Skilled readers also tend to experience the reading process as more automatic than less skilled readers do. Skilled readers make reading process decisions below the level of consciousness. Thus, skilled readers unconsciously, or with very little conscious effort, are reminded of the knowledge their prior knowledge. Unfortunately for design teams, that unconsciousness mental processing makes user testing of infographics more difficult.

Writing guideline say to move from general to specific and to move from given to new information [9]. In addition, in the explanatory text of most infographics, sentences must contain some level of causal connectiveness [28]. Comprehension requires making inferences and people prefer to move from more general to less general (deductive inference) rather than from less general to more general (inductive inference) [10].

People are sensitive to biases from recent effects or past experience. When interpreting information or making decision, the risk-taking or risk-aversion behavior is highly correlated with past experience, with the recent past having an unduly large affect.

In an interesting twist highly relevant to the graphical nature of infographics, although people's working memory and reading ability are highly correlated, with larger working memory equating to better reading skills [22], the research finding only applies to verbal material. Meta-analysis has revealed a highly complex set of inter-relationships between high and low ability readers and their ability to comprehend visual-spatial information [8]. In other words, an unstated assumption of graphics in general is that they work for people with lower reading ability. Although perhaps true for simple information, it cannot be assumed to support comprehending complex information.

4 Example Infographic Design Annotations

This section contains two example infographics with annotations that build on the importance of creating information relationships and helping comprehension.

Infographic Example
Stellar Evolution

Lacks any orienting information, including a title. Without adequate background knowledge, a reader will not understand what the infographic is trying to accomplish. The highly visual presentation of information can be difficult to grasp since the text fails to explain the images.

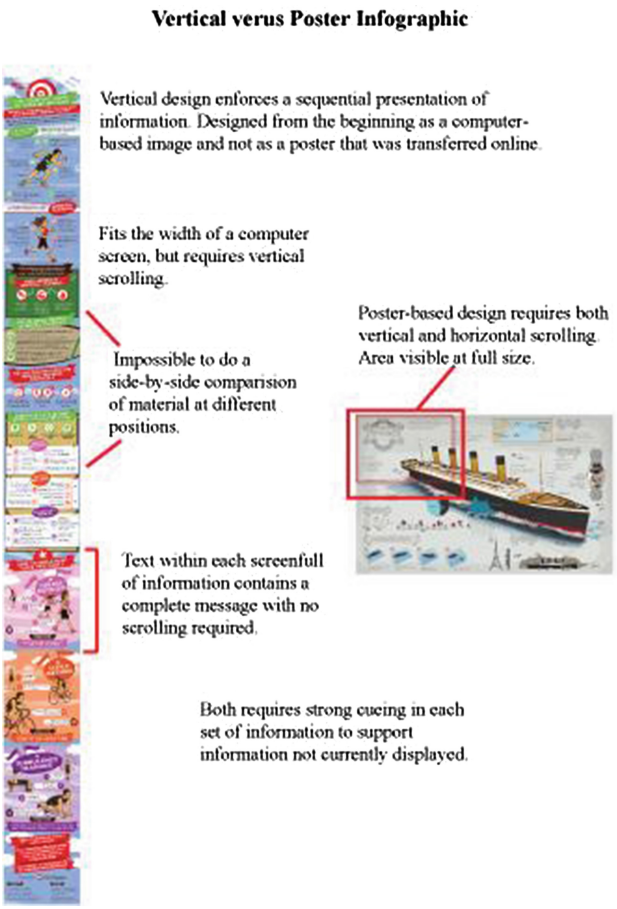
Has four Blue Supergiants. Needs to contain content to explain why they each have a different lifecyle or other issues that determine their differences.

Super shell and stellar nursery are dominating image but are not connected with the rest of the information flow. Its relationship and relevance are not clear to a reader without background knowledge.

Showing three types of supernovas, but a reader with background knowledge knows there are only two.

Gray arrows provide local orientation as the connect the individual star end-of-life sequence.

Source: http://www.jpl.nasa.gov/infographics/infographic.view.php?id=10737
Courtesy NASA/JPL-Caltech



5 Conclusion

With the growing use of infographics to communicate complex information, we must specifically look at how people read and understand them. Infographics are not art displays, but are tools to communicate information. Unless we understand how people comprehend information and how those mental transformations occur when they read the content, we cannot effectively design an infographic for complex information.

People come to an infographic for a purpose and with a goal, both of which require the infographics to communication complex information. A good infographic must maintain the complexity of the information while lowering the barriers to its comprehension.

A significant missing factor in infographic research is the comprehension level for the information. Issues of transforming the highly interconnected relationships inherent in complex information into a form that lends to itself to a comprehensive infographic—or

any other communication medium—remains an open research question that desperately needs more research. Most importantly, we need research into both how people comprehend an infographic and how they connect that understanding to the bigger picture.

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