

Information Visualization: Features and Challenges in the Production of Data Stories



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Abstract Information visualization is a communicative discipline that has experienced a continuous growth and development through the centuries. From its origins and first vestiges in the ancient civilizations of Egypt and Mesopotamia to the most up-to-date forms marked by the development of information technology, visual communication has been an effective tool. Furthermore, over the last few years its presence as a journalistic genre has been strengthened, especially with the emergence of new needs arising from the increasing availability of data. This chapter explores some of the challenges that information visualization has to face in our days, like the need to adapt the content to the particularities of different platforms and screens. The authors also address the particularities of interaction in these projects, one of their most salient features due to his usefulness in organizing and supporting storytelling.

1 From Being Engraved on the Rock to the Internet

Information visualization has been used as a tool for human communication in different ways throughout history. Thus, going back 4,000 years, it is possible to see how Mesopotamian, Sumerian and Egyptian civilizations developed visual forms for reporting and preserving information [23]. These first milestones in the visual representation of information, as well as many of the others that followed them, were very linked to emergent disciplines like astronomy or cartography [15]. Hence, history has shown us how humans have employed information visualization in different ways, not only as a method for exchanging knowledge, but also as a helpful tool for understanding the complexity of our world [39:28].

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Notwithstanding, after centuries of experimentation with the first maps, time-lines or navigation charts [20:22, 40:15] it is assumed that modern information visualization started with the contributions of the Scottish engineer and economist William Playfair [5:43]. Some graphic forms published in their main contributions *The Commercial and Political Atlas* (1786) and *Statistical Breviary* (1801) are still very popular and widely used nowadays. It could be the case of pie, line or bar charts [41:60]. Although it existed previous attempts of display statistical information through these—and some other—forms, the final years of the eighteenth century are considered one of the most expansive ages for data visualization. Advances in trading and the development of many modern nations required new forms to register and communicate social, demographic and economic data, fields where visualization proved its usefulness. Thus, in this context, some of the most remarkable contributions to the area were produced, building a solid basis for further works. This could be the case of John Snow's map of the cholera (1854), Florence Nightingale's chart on the death causes during the Crimean War (1858), or Charles Joseph Minard's chart on the Napoleon's Russian military campaign (1869).

All these examples, as well as many others, were turning points of further visualizations due to their ability to deal with a great amount of data, and their communicative effectiveness. These works became suitable not only for highly-specialized audiences, but also for the general public as it was possible to see with the success of visualizations like 1933 Harry Beck's Tube Map [8].

Another way of application for all this accumulated expertise was its use as a journalistic genre, whether as infographics or as information visualization. These are two forms of graphic presentation of the information with differences and similarities. Both infographics and data or information visualizations are visual representations of data. However, one of the main particularities of each of them is that infographics are often made up of multiple visualizations and other elements like pictures or illustrations, among others. On the other hand, data visualizations are the presentation of a single chart, map, graph or diagram [38].

The journey of the journalistic utilization of information visualization started in the British diary *The Times* on 7th April 1806 with an infographic about Isaac Blight's murder [29:110]. Initially, this form of information was very linked to disciplines like design and art rather than journalism. However, during the second half of the twentieth century, a new flowering of visualization took place, represented in journalistic infographics. Finally, one of the last steps of this advance was the exploration of all the features made possible by the development of computers and the arrival of the Internet.

Since the 1990s decade, the media have been exploring the potential of the World Wide Web as a space for the transmission of information. In this pursuit of the innovation information visualization has been playing—and still does—a central role as an element that can attract or catch readers' attention and communicate complex information at the same time [10].

2 Features, Function and Production of Journalistic Information Visualization

News media outlets are not oblivious to the current communicative context, marked by the importance of online communication and the growing presence of social media as spaces to access information. Although journalism has always been living in the middle of a battle for the audience's attention, this fight has become more important nowadays. Today, there are not boundaries for sharing content. Concepts such as trajectory or experience are no longer as relevant, while others, such as visibility or impact have gained presence.

The media are aware of these global phenomena and of the change in the audience's consumption habits. For this reason, they are trying to develop more attractive and impactful forms to attract the public to their content. In this regard, information visualization is being used as one of the formats with a presence in the above mentioned spaces [1] leveraging human preference for attractive and efficient formats [36], as it occurs with some forms of video or photographic contents.

Information visualization is currently experiencing a new golden age. This communicative tool has not changed its nature or conceptualization, which remains to be the visual presentation of complex data and information in a comprehensible manner [42] whose objective is “explore, make sense of, and communicate data” [16]. Nonetheless, it has experienced a metamorphosis process by adapting its narrative to the characteristics of the platform on which it is distributed. From print newspapers to smartphone screens, this way of communication information can play different roles [24], from illustration or accompaniment for the information to share the information by its own [46].

Nowadays, data visualization is “much more than visual representation of data” [17:19]. Its present importance as a journalistic tool, very linked to the growing availability of data [37] has modified some of the main traits of this genre. In this regard, Segel and Heer [34] show how technological development and the emergence of interactive visualization breaks with the supporting or accompaniment function to initiate a new path of works that users can explore, modify and personalize to create a unique experience. Furthermore, these visualizations seek to exploit all technical capabilities of the communication through the Internet by applying characteristics such as animation, interactivity or multimodality, among others [4].

One of the greatest needs for updating in the production of information visualization has been related to the composition of the work teams or units. In the past, the elaboration of infographics was an individual work of professionals more linked to fields like arts or graphic design guided by the needs of journalists and editors [6:8–9]. This idea is almost gone today, because the production of visual journalism—especially the interactive pieces—is built thanks to the contribution of a group of journalists with different areas of expertise and background [11]. Furthermore, this introduces another particularity, since the producers of graphic stories consider themselves to be journalist with full autonomy, fleeing from that label of artists or mere designers of the past [6:175].

Nonetheless, the production of data-based stories has certain needs in terms of time and response capacity to the fast-moving publishing model of our days, where news outlets share information constantly [37]. The production of news graphics—both static and interactive—, is normally more time-consuming than addressing information through text or even through another visual narrative like photography or video. Because of the implementation of the different stages of the production process—data search, analysis and cleaning; design phase and, finally, visualization—, the production of news stories based on information visualization usually follows two speeds. On the one hand, daily works that try to analyze the most up-to-date information and, when possible, breaking news. On the other hand, products that address foreseeable information or events known in advance that can be calmly developed, sometimes including some technical or design features that are not common in the visualizations produced on the same day. Hence, visual journalists try to combine these two strategies to be capable to answer the needs of the topical issues, but without forgetting the quest for experimentation and innovation inscribed in the DNA of information visualization.

Even so, the size of the media outlet can condition how it relates to the information visualization. Larger journalistic brands can deal better with the needs of this form of communication by creating multidisciplinary teams specialized in its production, units that sometimes work as an autonomous department by carrying out their own proposals, and sometimes in collaboration with other units within the newsroom. In contrast, some smaller news outlets have to adapt their routines, workflows and teams to the recent needs and innovations of this format. In a period of crisis for almost the entire media landscape, the optimization of the resources and the reallocation of tasks have become increasingly important. All of that to respond to the new needs and demands of the audience within the framework of the increasingly tight budgets of these organizations. Regarding information visualization, this has led smaller media companies to the redefinition of their journalists' jobs, sometimes after giving them a proper training [30].

Moreover, during the last few years we have witnessed the emergence of tools that facilitate the work of journalists in producing their visualizations. If ten or twenty years ago it was necessary to have extensive programming knowledge in order to create graphics—both static and interactive—, today tools such as Flourish, Datawrapper, Tableau or Carto have changed that reality [27]. These online tools—which usually have also a free version suitable for all audiences—have democratized access to information visualization production in many areas, and news production has been one of them. Thanks to these platforms, even journalists without deep computer or visual knowledge can enrich their news with graphics that help both professionals and readers to communicate and understand large sets of data, respectively. The use of these services makes it possible for the visual teams to carry out more difficult or time-consuming tasks in larger newsrooms. Additionally, brings smaller media outlets the opportunity of using this form of communication for taking advantage of all its effectiveness as communicative and attraction-getter instrument.

3 Interaction as a Mean to Support the Narrative in Information Visualization

Narratives are endemic in human culture, frequently used to “convey information in a memorable form that can engage and establish causal links” [33:361]. Although we cannot pinpoint when Man started this habit of telling stories, we know that their origin is ancient. And, despite having thousands of different forms of storytelling present in our everyday life, what we still instinctively associate with the concept of storytelling the image of an elder narrating an old fairy tale to a child [25].

Nevertheless, storytelling is not restricted to orality or textual depictions. Narrative is transversal to all expressive forms, even to music, which to musical semiotics has also been seen as a form of narrative [26]. Narratives are an intrinsic part of humanity, and each society imprints its identity and culture in its stories. Narratives are also a vital operation of the human brain, bound to the process by which it forms consciousness when interacting with an object [9].

Therefore, it is no surprise that journalism and narrative have walked hand-in-hand for a long, even emerging as a genre of its own. The genre of narrative journalism, also referred to as literary journalism, is often described as the genre that blends techniques from narrative fiction and applies them to non-fiction, maintaining the main characteristics of accurate, well-researched information. The transition to digital rekindled the narrative journalism flame with its potential of deeper audience engagement, coming from the medium’s enhanced interaction and immersion. Most often accompanied by a “revolution-esque vocabulary” [21:168], the decline of newspaper circulation and increased public distrust in news media are often highlighted by researchers as problems that can be mitigated by narrative journalism [43]. For instance, while advocating for the benefits of augmented reality as a medium for storytelling in journalism, Pavlik and Bridges stress “the potential [of digital technologies] to transform journalism and the media in several beneficial ways, including new forms of storytelling that might better engage citizens and provide more context, nuance and texture to reported events and issues” [28:4].

However, this long-term relationship has not always been peaceful. Narrative journalism remains the subject of endless debates and tensions between objectivity and subjectivity, partisanship and neutrality and ethics and aesthetics [21, 43]. Due to its potential to provide insights and further exploration of the data that can raise different points of view, visualization can be a tool to mediate the narrative journalism’s inclination to subjectivity and aesthetics.

To this day, visualization is more commonly used in journalism to support traditional storytelling forms as extra information or supporting evidence. Nonetheless, its use as an independent storytelling form, with traditional storytelling merely as support, is slowly and steadily growing. This growth can be seen all over the web, often as independent initiatives. However, the most outstanding effort, both in research and practice, unquestionably comes from journalism, an area where there has been a great effort to create multidimensional stories composed of other media besides text. In research, names such as Jeffrey Heer, Edward Segel and Alberto

Cairo stand out, and journalism outlets such as *The New York Times*, *The Washington Post* and *The Guardian* are blazing new paths in exploring the craft of integrating data with a compelling narrative.

Though the concept was introduced more than ten years ago by Edward Segel and Jeffrey Heer in the seminal work *Narrative Visualization: Telling Stories with Data* (2010), Narrative Visualization is still an emerging genre. The concept encapsulates complex data's effective communication to an audience engagingly using visualization and promoting insights, with a structured or semi-structured interpretation path [18].

Segel and Heer [34] identified three narrative structure tactics used in visualization. The first was ordering, which refers to the ways of systematizing the path users take through the visualization, and that can either be prescribed by the author (or linear), have no path suggested at all (random access), or need the user to choose a path among multiple alternatives (user-directed). The second was messaging, which refers to how a visualization communicates observations and commentary to the viewer and might be achieved through short or more substantial text: captions/headlines, annotations, accompanying article, multi-messaging, comment repetition, introductory text, summary/synthesis, among others. With ordering and messaging, interactivity is one of the narrative structure tactics identified, referring to the distinctive means to manipulate the visualization and how the user learns those methods (explicit instruction, tacit tutorial, initial configuration).

Interactivity is still intrinsically part of this process of interlinking narrative in visualization. Although it has been used in information visualization with several purposes, the more common being (1) making the data more engaging or playful and (2) showing the data in manageable portions (by partitioning it, either by browsing or by querying), for narrative visualization, interactivity opened up the possibility of adding new layers of content. These layers of content are vital for visualizations to act as stand-alone narrative news pieces.

Visualizations can, thanks to this added tier of content added most of the time in the form of annotations, present content that adds context, in addition to the data itself. This content's potential as a means to help a user make sense of the data is vast [22]. Nonetheless, interactivity in this scope is not only used to support the narrative. If we define information visualization as “the use of computer-supported, interactive, visual representations of abstract data to amplify cognition” as does Card, Mackinlay and Shneiderman [7: 7], it is practically impossible to dismiss the role of interactivity.

Because visualizations are fundamentally dynamic, the interest in researching interaction techniques in visualization has been ever-growing. In addition to studies on its efficacy, efficiency, or introduction [3, 12, 13], several studies propose information visualization interaction taxonomies. The most well-known is unequivocally the Visual Information-Seeking Mantra by Shneiderman [35]. However, in 2015, we found the necessity to build a broader interaction techniques taxonomy, which can be seen in Table 1, to include more modern interaction techniques, such as participation or gamification [19]. Later in 2020, we derived this taxonomy to the particular case of Spatio-temporal (ST) Visualization since a generic interaction taxonomy cannot

Table 1 InfoVis interaction taxonomy

Interaction technique	Description
Filtering	Only show me the data in which I am interested
Selecting	Mark or track items in which I am interested
Abstract/elaborate	Adjust the level of abstraction of the data
Overview and explore	Overview first, zoom and filter, then details on-demand
Connect/relate	Show me how this data is related
Reconfigure	Give me a different arrangement of the data
Encode	Give me a different representation of the data
History	Allow me to retrace the steps I take in the exploration of the data
Extraction of features	Allow me to extract data in which I am interested
Participation/collaboration	Allow me to contribute to the data
Gamification	Show me the data in a more playful way

Source Figueiras [19]

be applied to analyze ST visualizations without several adjustments [31]. We predict that new derivations are also possible to other particular visualization usage contexts.

Using narratives in the context of visualization, supported by interactivity, is an intricate editorial process characterized by a sequence of rhetorical decisions at various stages. First, to understand how interactivity can support the narrative, we need to understand the commonly used narrative patterns. In 2016, as an outcome of a workshop on Data-Driven Storytelling in Dagstuhl, an interactive browsable collection of narrative design patterns with examples was created. According to Bach and colleagues [2:111], “a narrative pattern is a low-level narrative device that serves a specific intent”. In NAPA Cards¹ the 16 patterns (Incorporating the audience, Repetition, Juxtaposition, Breaking the fourth wall, Humans behind the dots, Make a guess, Rhetorical question, Familiar Setting, Call to action, Gradual visual reveal, Defamiliarization, Convention breaking, Speeding up, Concretize, Meaningful use of space and Silent data) are grouped into five higher-level pattern groups: empathy/emotion, engagement, framing, flow and argument/argumentation. This typology derived from an initial open-ended question regarding the purpose of the use of narrative, the existing patterns, and its application. The narrative patterns can be combined or used on their own to create compelling data-driven narratives and are not exclusive for visualization, being easily applied to different data stories.

¹ <http://napa-cards.com>

To understand how meaningful interaction techniques are commonly used to support these narrative patterns, we searched for a representative visualization example, which can all be seen in Fig. 1, for each narrative pattern and identified which interaction technique is used to support it. The intent is not to bound interaction techniques and narrative patterns but to learn which narrative patterns we could not find any interaction technique supporting it. As can be seen in Fig. 2, we found the use of the narrative techniques Incorporating the audience, Humans behind the dots, Make a guess, Familiar Setting, Call to action, Gradual visual reveal, Defamiliarization, Speeding up and Concretize.

Some of the narrative techniques that we did not find a utilization example that resorts to Interaction, such as Breaking the fourth wall or Rhetorical question, were often found in examples that did not use Interaction to support it. In fact, most of these narrative patterns that we found not to be supported by interaction were catalogued in NAPA Cards in the higher-level pattern group framing, which according to the authors “builds the way facts and events in a story are perceived and understood through narration” [2:116]. These narrative patterns are often achieved with language resources such as Figurative Language or dialogue. This is the case of *How many households are like yours* which uses a rhetorical question in its visualization title that ultimately induces the user to introduce the data for his family and compare it to other American families. This action, however, is not forced or fomented by any interaction technique. Other framing narrative patterns that do not fit the same pattern were Juxtaposition, Convention breaking, Meaningful and Silent data. The only narrative pattern that is not catalogued as framing and that we were not able to find and examples using it resorting to interaction was *repetition*. This narrative pattern was catalogued by Bach and colleagues [2:111–116] both as flow and argument/argumentation. The latter is a linguistic resource that serves “the intent of persuading and convincing audiences” [2:114] and therefore harder to occur supported by interaction techniques.

We also found examples of narrative techniques supported by more superficial interactions such as scroll activated animations. Several examples of Gradual visual reveal would fit this Interaction. In examples such as *How Big is Space* would easily fit this case. In this example by *BBC*, the user pilots a rocket through the Solar System as he/she scrolls the page down. On the way down, the user accesses information such as how close comets have come to our planet, the farthest traveled by a human being and how long the trip on the Starship Enterprise. Here, scroll activated animations are used to provide the narrative sequence.

This type of reflection on how and what interaction techniques are commonly used to support these narrative patterns allows us to have a rule of thumb for the application of both the narrative patterns and the interaction techniques. However, creating compelling visual data stories is not an easy task, and beyond being a team, labor-intensive process, its creation requires expertise, iterations, feedback and essentially a deep understanding of both narrative and visualization. Following the creation of a narrative visualization, there is an implicit decision-making process where several steps have to be taken into account, and their articulation is vital for the success of the visualization. In this process, having clear guidelines can

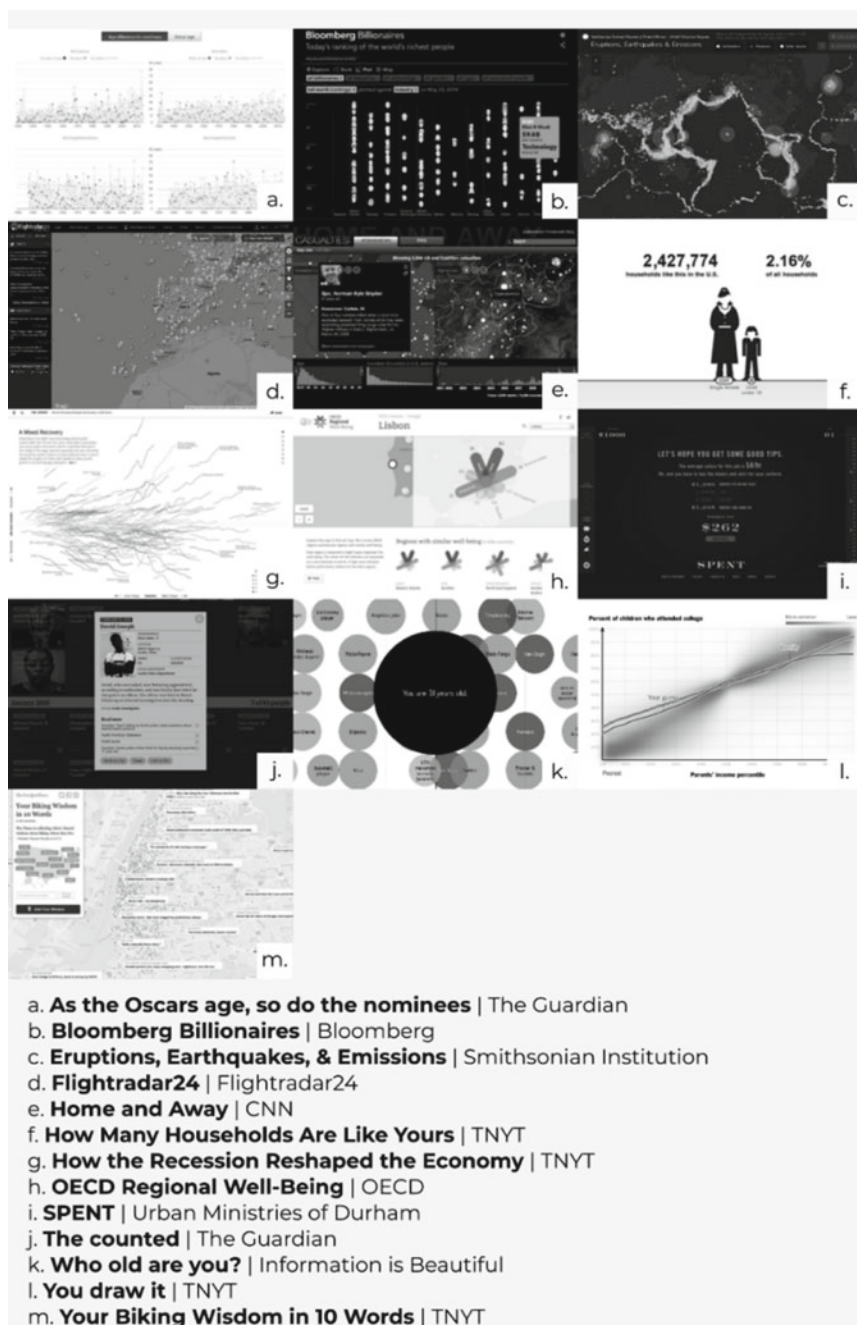


Fig. 1 Gallery of examples used. Own elaboration

NARRATIVE TECHNIQUE	EMPATHY	ENGAGEMENT	FRAMING	FLOW	ARGUMENT	INTERACTION TECHNIQUE	EXAMPLE
Incorporating the audience				•	•	Filtering	Home and Away
				•	•	Selecting	How Many Households Are Like Yours
				•	•	Participation / Collaboration	Your Biking Wisdom in 10 Words
Repetition	•	•	•			•	•
Juxtaposition	•	•		•	•	•	•
Breaking the fourth wall		•		•	•	•	•
Humans behind the dots		•	•	•	•	Overview and Explore	The counted
Make a guess	•			•	•	Gamification	You draw it
Rhetorical question	•	•		•		•	•
Familiar Setting		•		•	•	Filtering	OECD Regional Well-Being
				•	•	Selecting	Who old are you?
Call to action	•		•	•	•	Gamification	SPENT
Gradual visual reveal	•	•	•		•	Overview and Explore	How the Recession Reshaped the Economy
Defamiliarization	•	•		•	•	Reconfigure	As the Oscars age, so do the nominees
						Encode	Bloomberg Billionaires
Convention breaking	•	•		•	•	•	•
Speeding up	•	•	•		•	Abstract / Elaborate	Eruptions, Earthquakes, & Emissions
Concretize	•	•		•		Encode	Flightradar24
Meaningful use of space	•	•		•	•	•	•
Silent data	•	•		•	•	•	•

Fig. 2 Crossing narrative techniques and interaction techniques with examples. Own preparation

influence success. For the particular usage scenario of Spatio-temporal visualization, we found four decision categories (Intent, Spatio-temporal, Interaction and Narrative Elements) that can ease structure the design process [32]. However, this process can be easily adapted to other usage contexts.

4 An Answer to the Challenges of Big Data and the Variety of Languages and Screens

Today, we live in a world where almost everything is quantified and recorded as data. Over the years, we have observed how we have stored a large volume of data, but sometimes we find it difficult to relate them and, especially, to communicate them.

In short, our society has been undergoing a continuous process of datafication [14], and tools for the communication of this data are needed.

Journalism has become an indispensable intermediary among large sets of structured data and the audience. Some reports are the consequence of analyzing and studying the reality of these almost infinite data tables with the unique objective of finding the story behind them. Over the last few years we have, therefore, witnessed how information visualization has gained presence in this type of stories. Sometimes visualization is used as a complement that enriches the journalistic pieces. Nonetheless, the importance of information visualization in these cases is growing, and more and more data journalism stories are being produced only by using information visualization.

The emergence of this data-based way of doing journalism has also modified the visuals teams and professionals' routines and characteristics. Until the first years of the twenty-first century, data and stories should be retrieved by journalists themselves. With the emergence of open data portals and other initiatives for sharing large sets of data, news media outlets—and also graphic desks—discovered a new group of sources with a very high informative potential [44:140]. This new reality was both an opportunity and a challenge. Suddenly, visual journalists were able to access not only a new corpus of data, but also a whole host of potential stories to communicate to their audience through information visualization. However, as highlighted before, these changes made necessary the reconfiguration of the newsrooms and the creation of teams with different profiles and backgrounds. All of that in order to give an answer to the high complexity of these data-driven stories.

Another important challenge for information visualization is the adaptation to the changing environments in news consumption. Although this journalistic genre has demonstrated its capacity for adaptation over the years, sometimes it made necessary the adaptation of the production workflow. Once more, there is a difference among larger and smaller news brands. Larger ones, thanks to the size of their visual teams can deal with the production—or the adaptation—of visual content to the different screens. Nonetheless, smaller newsrooms or at least newsrooms with a smaller visualization unit do not have this responsiveness [45:292].

Visual teams and their professionals live in a continuous process of retraining with the unique objective of being able to deal with the most current technologies [44:146]. This quest for updating goes so far that sometimes many of the technologies adopted in the newsrooms enter through the visualization team, and they are the first to test automation or virtual reality in their works [6:12]. In fact, as shown in this chapter, information visualization has experienced a lot of changes and adaptation processes over the last few decades, and it is expected that this need for adaptation will continue to be present in both the renovation of visual languages and the renewal of production processes. All of that with the objective of maintaining its efficiency and ability to communicate complex information without losing all its potential as attention getter.

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