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FROM INFOGRAPHICS TO POST-INFOGRAPHICS

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Infographics: Past and Present

Infographics are one of the well-known representations of the information visualization area. Mainly because this discipline became popular due to its adoption by the newspapers, initially for their print editions and for their online spaces then. Nonetheless, infographics could be considered as one of the journalistic genres with a major development during the last few years (Engebretsen, Kennedy & Weber, 2018). These advances are explained by the big progress of data recording, retrieval and analysis as well as the improvements in visualization and design technologies with the appearance of new tools that have simplified the infographic journalists' job. Furthermore, this progress has resulted in the advent of new forms of visual communication through infographics that did not exist in the first stages of this genre.

Information visualization origins are linked with the headways that visual culture has experienced through history. Hence, landmarks of the human visual culture like the Code of Hammurabi or the Egyptian hieroglyphics, among many others, are considered crucial for understanding how it is possible to translate data into visual forms (de Pablos, 1999, p. 22). Even so, the biggest advances in infographics were made after the popularization of the genre in the newspapers. Many experts consider that William Playfair's *Commercial and Political Atlas* and *Statistical Breviary*, published in 1786 and 1801 respectively, had a major contribution in the development of infographics by utilizing many of the visual forms majorly utilized even nowadays by almost all media outlets (Friendly, 2008, p. 24). Similarly, visual examples like Doctor John Snow's 1854 cholera map or Charles Joseph Minard's 1869 diagram on Napoleon's Russian campaign have provided a fertile ground for the birth of news graphics (Cairo, 2008, p. 43; Tufte, 2001, p. 40).

The origin of news infographics remains unclear, even after years of research. Authors like Tascón (2011, p. 22) found an example of this genre in a 1638 report. It was the description of a volcano placed in the Azores. On the other hand, Cairo (2017, p. 37), points out to *The Daily Courant*'s 12 September 1702 map about the Anglo-Dutch attack on Cádiz harbour as the first example of newspaper infographic. Notwithstanding, there is broader agreement among researchers in tagging the sequence about the murder of Mr Isaac Blight, published by *The Times* on 7 April 1806, as the first example of infographics in press (Peltzer, 1991, p. 110).

Even without consensus about what could be the first example of this genre in the daily press, all the provided three as well as other ones have contributed to the strengthening of this discipline. Because of this, during the late 19th and the 20th centuries the pages of newspapers of different parts of the world adopted these visual elements as one of the ways to communicate information and data, especially in the American and British context. Nevertheless, this adoption had highs and lows. As Friendly (2008, p. 37) highlights, infographic development through these centuries combined big advances with periods where other forms of communication played a more central role, both for newspapers and for other publications.

Over the years, infographics were adopted by the principal newspapers all over the world as a consequence of a more modern approach in their design (Barnhurst & Nerone, 2001: 190). Even so, the launch of the *USA Today* in September 1982 is often pointed out as a major milestone to understand subsequent advance of newspaper infographics (Cairo, 2017, p. 50). This publication contained many innovative features, brought directly from the television, a medium whose popularity was growing constantly by that time. The novelties introduced by the *USA Today* were adopted afterwards for many other media outlets and creating a new style of more simple but very functional visualizations (Martínez Arias, 2016), often embellished with illustrations. That was the style of designers like Nigel Holmes or Peter Sullivan, who led the infographic department of renowned newspapers and magazines in the United States and the United Kingdom, mainly during the 1980s and 1990s.

As previously mentioned, technology has triggered many changes in the visual genre of infographics, both in the design and data management sides. In fact, the development of new software tools has provoked the emergence of what scholars named as a new genre: multimedia, interactive or online infographics. This new form of visual communication differs from his static matrix in the utilization of the Internet and online media's three main features: interactivity, hypertextuality and multimodality (Cores, 2003). Multimedia infographics have been evolving since the arrival of the first online media outlets by the middle of the 1990s. For this reason, it is possible to highlight the decade between 1995 and 2005 as the first expansive period in the use of this communicative form, as pointed out by Cairo (2017, p. 77). Through the years, the appearance of free and public tools combined with the development of instruments designed specifically by news media outlets provoked a constant growth in the production of multimedia infographics with a remarkable increase of their popularity.

Likewise, the production of graphics for online platforms has been benefited with the developments in areas like mobile communications or the increasing availability of data. Therefore, the continuous improvements in devices like smartphones, tablets or laptops (Doctor, 2016) has made that nowadays visual communication forms as infographics now play a central role in the communicative strategies or major media outlets all around the world. In the same way, the growing availability of data has been another important factor in the magnification of information visualization in general and, more specifically, of multimedia infographics. Datasets originated and saved in the fields of big data and open data as the philosophy that fights for the liberation of data, have thickened the number of sources available (Engebretsen et al., 2018). Because of that, both individuals and, above all, media outlets can access, manage and communicate these datasets to larger audiences, by extracting the stories behind them (Smit, de Haan & Buijs, 2014).

Moreover, newsrooms have introduced the utilization of online tools like *Infogram, Tableau, Flourish, Carto, Highcharts* and so on (Ojo & Heravi, 2018) as part as their productive routines. These tools facilitate and accelerate the elaboration of news graphics, mainly due to the ease of using them and embed those contents on any website. In consequence, even journalists without much experience in the production of infographics can supplement their pieces with interactive visualizations with varying complexity degrees.

Hence, multimedia infographics are entirely linked to technological developments. In this regard, information visualization has always adopted those devices and tools that could improve all the stages of the production process: data retrieval and management, design and publication. Example of this are the continuous advances in one of its main features, interactivity, whose presence and use has experienced manifold changes over the past few years.

The Role of Interactivity in Post-infographics

Journalism has always been about uncovering relevant stories, gathering information, and communicating the facts in a way that can be clearly understood, but also exciting (Kovach and Rosenstiel, 2007). Although journalism is no stranger to data, the consciousness that data surrounds some of today's most relevant stories is growing, and this involves journalists embracing new forms of presenting this data, which can be very hard to understand. Writing is no longer the primary choice for a semiotic mode, and coding and visualizing became pivotal elements of journalistic storytelling and the way journalists understand and do journalism (Weber et al., 2018).

This consciousness helped create a professional community with an interdisciplinary set of professionals with an extensive set of skills, composed, among others, of journalism professionals and academic researchers in the areas of visualization, new media and design. Visualization is at the heart of these data-driven stories, which are often visually rich and multimedia. However, there is no consensus regarding the many names used for these new media artefacts. While the research community has favoured the term *information visualization*, especially when

talking about "computer-supported, interactive, visual representations of abstract data to amplify cognition" (Card, Mackinlay & Shneiderman, 1999, p. 7), media tends to use terms that maintain the link with printed infographics or to use more encompassing terms such as *data visualization or data stories*, linking with the now widely popular *data journalism*. The two communities started far apart but are slowly closing the gap, even though the knowledge created by the research community develops slower than practice, which has been more receptive to adapting novel techniques to storytelling environments.

Following the long tradition started by analogue environments, these new narratives emerged as a way to tell stories supported by facts extracted from data and tightly integrated with visual representations, now in a new media, and with the possibility to add a layer of interactivity. These new narratives have the potential of democratizing data and helping the public make informed decisions. With the democratization of web-native technologies, data-driven visual representations became truly visual, being able to reach a wider audience. Until these technologies arrived to modern browsers, most web-based visualizations relied on browser extensions such as Flash and Java (Dörk, 2012), which restricted the number of people that could see them (Murray, 2017). JavaScript solutions, on the other hand, runs in a wide variety of environments (cross-browser) and is accessible to people with disabilities, therefore has gradually become the de facto standard language for rendering rich interactive content web pages. Several JavaScript libraries, tailored for visualization, have been developed, the most popular being Data Driven Documents (D3), an open-source JavaScript library usually used to generate Scalable Vector Graphics (SVG) graphics, a vector image format long supported by browsers but until recently underutilized. The possible reasons for its popularity might be its use of web standards – "HTML for page content, CSS for aesthetics, JavaScript for interaction, SVG for vector graphics, and so on" (Bostock et al., 2011, p. 2301) – the fact that SVG graphics perform well in high-resolution displays, which are now becoming increasingly popular, and the fact it is an open-source project that allows developers to build on top and improve it.

Using Interactivity to Make Data Manageable and Engaging

Post-infographics employ interactivity for several purposes, the more common being: 1) showing the data in manageable portions, for instance, by partitioning it, either by browsing or by querying, and 2) making the data more engaging or playful. It is defined as the capability to act on what will show up on the screen and is supported by actions that the user performs (interactions techniques), to which the system provides feedback (Liang et al., 2010). Interactivity is often paired with animation, a pairing that, according to C. Gonzalez (1996), makes these environments more enjoyable and improves the accuracy of decision-making tasks.

Users find it very challenging to understand large, unorganized datasets, but grouping and aggregating the data facilitates both the understanding and the analysis of the data, therefore, making it possible to reduce users' search and working

memory load (Yi et al., 2008), and consequently avoid a feeling of information overload. By allowing us to reduce the degree of complexity, interactivity can be a valuable asset to reduce the user's cognitive load and improve his/her tracking capabilities, amplifying human cognition, and linking the presented visual information with real-world knowledge. In addition to having interactivity to have visual stories with less clutter and consequently more appealing to the public, it is also essential to have the data simplified, organized and labelled.

In addition to reducing complexity, interactivity also tends to lead to better engagement, especially when dealing with data because presenting the data visually improves its understanding, but allowing the user to manipulate it is even more engaging. Engagement, the power to attract and hold the users' interest in order for him/her to further explore, is particularly important in fields that benefit not only from the time the user spends exploring the data but also from users sharing. The news media is one of these fields: if users spend more time exploring a data-driven story that translates into more valuable space for advertisers. Additionally, if users are interested in the data-driven story enough to share it with their friends, either through social media or by word of mouth, it means that the page where the story is featured will reach a wider public, generating more revenue from advertising.

Filtering, selecting, abstract/elaborate, overview and explore, connect/relate, history, extraction of features, reconfigure, encode, participation/collaboration and gamification are some of the interaction techniques that can be found on these new media artefacts (Figueiras, 2015). Different interaction techniques will play different roles in the navigation and interpretation of the story.

Exploration and Explanation

Interactivity, together with narrativity, plays a definitive role in the navigation of the user in post-infographics. Frequently, it defines the level of flexibility (exploration) and interpretation (explanation) provided in the story. This notion of exploration and explanation is also linked to the idea of stories being more reader-driven or more author-driven (Segel and Heer, 2010).

In more exploratory stories, a trend observed in several sophisticated post-infographics, authors often rely on interactivity to provide the users with the possibility to explore the data and find appropriate answers to their questions. Providing ways for the users to find the answers autonomously frequently is a better option than presenting answers to what the creator believes are the users' questions, making it explanatory. A more exploratory scenario gives users more freedom and control over how they experience the story and prevents the author from making catastrophic storytelling decisions that prevent users from enjoying the story. Moreover, it is complicated to predict what the users' questions will be, and, being visualization a discovery tool, limiting its potential to provide insights is a mistake.

As argued by Dörk, Carpendale et al. (2011), serendipity, the phenomenon of making pleasant discoveries or finding valuable things by chance, is one of the crucial aspects of the information-seeking process. Therefore, this opportunity to

make discoveries by accidents and sagacity should be given to the user as often as possible. People are used to finding relevant information without actively seeking, either through friends and family or skimming through media, and seem to enjoy these serendipitous encounters because they are driven by curiosity into exploring further. According to Thudt et al. (2012), by nature, visualization seems to be able to enhance serendipity, especially when these incorporate design goals for promoting serendipity such as multiple visual access points, highlighting adjacencies, flexible visual pathways, enticing curiosity and playful exploration.

In order to allow for a proper exploration, it is essential to reduce complexity. Reducing complexity is one of the reasons to use interactivity when working with data. It facilitates both the understanding and the analysis of data, and, according to Keim (2002), having the data in smaller portions is essential when exploring large datasets. Keyword search and filtering interfaces can be useful for reducing complexity but are a threat to serendipitous information encounters, but strategies such as "similarity-based suggestions and visual information surrogates" (Dörk, Carpendale et al., 2011) can be used to promote these encounters while clearing the clutter.

In opposition, explanatory stories communicate a particular narrative chosen by the author, providing context and interpretation. These are essential for showing viewpoints about data and providing storylines for the user to follow. Segel and Heer (2010) call these stories author-driven and identify that these have a strictly linear path, relying heavily on messaging.

In order to maintain a robust exploratory focus, these data-driven stories are often finite, with a linear progression, and their structure is often a combination of interactive visualizations with long-form text and other linear sequences. The author decides what and how to show, and with interactions will support the story flow. Stories with a robust explanatory structure regularly use interactions such as selection and emphasis to guide the focus of the user. The explanatory nature of the story can be explicit, or it can be more subtle.

Although guidance from the author is vital to understand the overall story, structures that are heavily author-driven and over-curated tend to be tedious. This fact becomes an even bigger problem with proficient users.

Most post-infographics will fall along a spectrum between the author-driven and reader-driven approaches. Considering that the purpose of storytelling is to communicate a narrative, most of the time, these post-infographics are neither completely exploratory, because these include storytelling elements, or solely explanatory, because interactivity is a defining aspect of post-infographics and both data analysis and personalized navigation are valuable assets. Structures that are too exploratory and have little author-driven guidance can impair comprehensibility and engagement, and the user can be left under or misinformed.

Therefore, the challenge is combining exploration and explanation in creative new ways and balancing the two approaches in order to build visual stories that are easy to understand, appealing, and that still provide room for exploration. Segel and Heer (2010), who argue that most of what they call narrative visualizations do not fit

the author-driven (explanatory) versus reader-driven (exploratory) dichotomy, identified three possible structures: martini glass structure, interactive slideshow and drill-down story. The first is a structure that begins with an author-driven approach, initially using questions, observations, or written articles as introduction and then opens up to a reader-driven stage where the user is free to explore the data interactively. The second has a more linear path following the typical structure of a slideshow but also including some interaction on each individual slide, allowing the user to explore particular points of the frame he/she is in before moving forward on the author-driven path. Finally, they present the most reader-driven structure, which enables the user to choose to explore different details of the story freely despite maintaining the user in the general framework, but the author of the visualization still has the responsibility to point the user to the possible paths.

Interactivity and its Relation with Contextual Information

Interactivity opened up the possibility of adding new layers of content to post-infographics. With this additional layer of content, these artefacts can present content that adds contextual information in addition to the data itself. This content that can be provided on demand has the potential to help a user make sense of the data (Hullman, Diakopoulos & Adar, 2013). Using interaction techniques allows users to filter selected queries, reconfigure the dataset, adjust the scale, adjust the pace of animated elements, and many other possibilities, reshaping the layout and allowing users to adequately investigate and find appropriate answers to their questions (Lima, 2009).

Providing Narrative Elements

Research has shown that the audience prefers short moments of storytelling that they can access if they feel the urge, rather than having dense storytelling that they have to follow carefully. Therefore, annotations are often used to provide context that otherwise would be very difficult to provide, facilitating the user's interpretation, suggesting conclusions and generally guiding the user's interaction.

When provided in smaller moments of storytelling, this context information is more comfortable to assimilate than a dense article. Furthermore, mainly when provided as details-on-demand, these annotations support the free exploration of the data and its context stories. The user is not obliged to access the information unless he/she is interested in it, improving his/her enjoyment.

Certain types of visualization also seem to be more suitable for data stories. Since one of the fundamental attributes of stories is the fact that these provide a temporal structure (Kosara and Mackinlay, 2013), which does not need to be necessarily linear, visualizations that are able to not only introduce storytelling elements but also have a story flow they will potentially be more successful. For instance, visualizations that provide some temporal structure or sequence, such as timelines, time series and small multiples, have been found to work

better than exploratory visualizations (Brehmer et al., 2016; Figueiras, 2014; Hullman, Kosara & Lam, 2017).

Interactions such as hover, click details, player or media controls can provide this context, making the data more meaningful. This context can be shown resorting to several different types of narrative elements such as audio or video narration, annotation tooltips, captions and labelling.

Linking Elements through Interaction

In some cases, the context can also help guide the user through the author's intended structure. Linking elements through interaction can be used to connect different views of the same data, to follow the intended narrative, and to link data points to storytelling elements. This strategy is notably essential when dealing with complex data and complex representations.

For instance, having multiple views of the same data is both helpful and challenging. When using interaction to connect two or more views of the same data, it is possible, for instance, to follow a change of representation in one view and understand how it affects the representation in the other. This methodology is commonly called brushing and linking. Having this possibility is especially necessary for the visual exploration and analysis of large, structured data sets.

In the same line, linking plays a significant role in guiding the user through intricate story structures. For example, in a complex flowchart, with multiple arrows connecting the different components, being able to highlight each connector assists the user in following the narrative.

The feature to link data points and different storytelling elements, allows the user to get contextual information and immediately relate it to the data. This feature is especially valuable in long formats where having the ability to scroll through the story linking text to a visualization, specific data points in a visualization, or even to a main visualization that accompanies the entire story (usually a timeline as in Schweizer Radio and Fernsehen long format on Federer's achievements over the years, 20 Jahre 20 Titel).[1]

The leading interactive elements used for highlighting are *click highlight* and *hover highlight* (Figueiras, 2013). Click highlight is the interactive action of highlighting or emphasizing a content (text, image, pictogram, etc.) when a computer user moves the pointer to a specific location on a screen and presses a button on a mouse, usually the left button (click), or another pointing device. Similarly, hover highlight is the action of highlighting or emphasizing content on mouse-over or mouse hover (raised when the user moves or hovers the pointer over a particular area).

Supporting navigation and structure

Interactivity also plays an important role in creating a structure and navigation in the story. Since data stories are often in a longer format or at least more intricate it

is necessary to facilitate de reading resorting to navigation and structural elements that can help to clear the clutter. Techniques such as scroll-activated animations and steppers are frequently used, even if these make the story more explanatory. According to Weber et al. (2018), journalists often favour narrative, explanatory and argumentative elements and structures because they aim to convey a clear message.

Scroll-activated animations, often called scrollytelling when used as a narrative device, are a new trend for interactive navigation. These consist of animations or effects that unfold and slide across the screen triggered by touchscreen, computer mouse motion or keypress. Scrollytelling, as it also happens with techniques such as linking between text and visualization and brushing and linking, creatively constraining the reader (Weber et al., 2018), therefore, lead to a more explanatory experience.

However, there are several usability problems in scrollytelling (Kosara, 2016). Some of the issues are as follows: page load takes longer and performance on some devices may be affected; it is difficult to return to an item that interested the user; when misused, animations designed to add aesthetic appeal decrease content consumption and get in the way of the user; and scrolljacking, since to make these effects, the creators of the story often have to change the scroll, manipulating it to not stop in the middle of the effects or jump to specific parts, which if it is realized by the user may make him/her feel frustrated or hijacked.

Another interaction technique that can be used to support navigation in a narrative structure is steppers, which can be an alternative to scrollytelling. Steppers consist in splitting the story into steps, sequential frames like a slideshow or a comic strip that unfolds with each click (e.g. For the Elderly, Diseases That Overlap by *The New York Times*). The user is supposed to have on each page new information that he is gathering and combining in his mind to the complete story. This type of storytelling, which imposes a strong linearity, is simple and familiar, but it can also become less engaging if there are too many steps to follow.

Both scrollytelling and steppers become much more challenging when they include more than one visual representation. This challenges the creator to make good decisions on how to make a sequence that is understandable and compelling to the user (Hullman et al., 2013). Therefore, the author has to resort to transitions that work for these formats, such as dialogue transitions, which can be question and answer sequences, or a sequence of information about who, what, when, where, why and how; temporal transitions, which can be either chronological, inverted chronological or future chronological order (the latter is when, for example, they show the possible effects of something, for example the effects of drought or rising sea level); causal transitions, which are sequences of explicit cause or alternative realities (may even be several different scenarios); granularity transitions, from general to specific, or vice versa; comparison transitions, which involve comparison of dimensions or measurements; and spatial transitions, or spatial approximation sequences (several different zoom frames).

Development and Changes of Infographic Content Production and Prospection about Possible Changes in the Future

The Rise of News Infographics – Where Next?

The rise of data visualizations in today's news speaks both to the utility, and to the efficiency of the form; they are in many ways the ideal medium for today's post-industrial (Bell, 1999[1976]), information-oriented network society (Castells, 2000). A salient feature of modern life as we live it today is information overload (Toffler, 1970), a problem that is increasingly intractable due to the extraordinary and unprecedented rates at which new data are being produced and consumed. This data glut has presaged the rise of (relatively) new jobs and professional roles that require skills in data collection, analysis and presentation (Patil 2014) in newsrooms, as much as elsewhere in today's knowledge economy. As the quantity of data around us increases, it is argued, visualization moves from being a practical tool to being an essential one (Gatto 2015, p. 5).

News, as generations of newsroom ethnographers have shown us, is a conventional construct; and different subdivisions of newswork are constitutive of their own peculiar conventions, often caught in the tension between organizational and professional norms, and values. What happens to our news, then, when data visualizations become core to these conventions? And what effect might this have on tomorrow's data visualizations?

New Forms: From Information Literacy to Information Sensing?

The centuries-long dominance of the written word and of the book is giving way to the image, and to the screen (Kress, 2003). Consequently, scholars have for some time been pre-occupied with questioning what literacy means after this visual turn. Both highly efficient and effective in communicating data, and seemingly unburdened by the complexities of written language, data visualization is, it is argued, changing what it means to be literate in the 21st century (ACRL, 2011).

As data visualizations in our news have shifted from print to screen, and indeed as they move beyond the screen into (for example) augmented reality, the affordances (Norman, 2013 [1988]) associated with new media and the data they make available, will become increasingly difficult to predict. However, the context of this shift is perceptible already. The increasing atomization of news as it has gravitated online, and the increasingly sophisticated use of user metrics by news organizations in this process, threaten to unbundle the marketing principle of the "attractiveness of orchestrated variety" (Conboy, 2002, 75) that drove news production through the 20th century. Some news audiences are perfectly comfortable with relatively sophisticated graphical forms, from the sciences (including scatter-plots). On the other hand, some audiences do not understand these forms; and indeed, some audiences do not like certain graphical forms (Dick, 2014). In future, the forms that data visualizations take will incorporate a range of factors, not least audience affect

(at highly segmented, and even at the individual level), an approach that may necessitate a wider pool of forms; and a wider scope of variation in the complexity of data visualizations in news.

What will be the future for data visualizations now that we have already moved beyond the mechanical reproduction of text, into a world where reality may be mechanically reproduced by 3D printers? As information overload (Toffler 1970) continues unabated, and as new technologies (building on, for example, augmented reality) emerge in order to bring other senses into the process of news consumption (and to the process of knowledge creation in society more broadly), it is safe to assume that news culture will evolve, on Marshall McLuhan's terms, towards extending the full (or at least a fuller) range of senses within the human sensorium. In this new environment, data visualization will increasingly incorporate (or will be incorporated into) alternative, extra-sensory ways of knowing.

It has been suggested that, in a world where our engagement with data increasingly involves haptic sensations, we may be moving from a state of data literacy to one of data sensing; where personal data are explored by touch, thus making possible new ways of knowing (Lupton, 2017). Michael Schudson was surely right to argue that conversation is not the soul of democracy (1997). It seems likely that the age-old debate concerning the functioning of public spheres, deliberative democracy and the respective roles of the eye and the ear in political deliberation may be rendered obsolete by the inclusion of other hitherto unexploited senses in future processes of knowledge creation. Smell, touch, even kinaesthetic sense, may contribute to our engagement and interaction of the world (and data) around us; and these may in turn shape future generations of data visualizations in our news, as in wider knowledge work. Best practice developed for two-dimensional media, and developed with the singular goal of minimizing optical illusion, will need to evolve to accommodate new (augmented) realities.

Lev Manovich (2018) suggests that data visualization will increasingly become a means of creating and of conveying knowledge about society in a cultural paradigm he calls *media analytics*. New technologies will help us, he suggests, to move beyond reductive theories and ways of thinking about culture, beyond categories that were shaped by those obsolete technologies that were used to gather and analyse data in the past. Of course, visual technologies are not necessarily superior to textual ones (and, no doubt, haptic media will not be either) in helping us to form new knowledge about the world. All will have their strengths and limitations, and will need to be accommodated if future modes of analysis and interpretation, in news as in wider knowledge work.

How then will news audiences learn to use, and familiarize themselves with these new media?

Uses, Gratifications and Affordances of Future Data Visualization

In the past, news audiences encountered infographic forms via a range of mass media: in late 19th-century almanacs, year books and gazetteers, and subsequently

in popular magazines. A relatively small number of school children encountered them in mathematics text books in the early 20th century, and by the 1930s, though not a regular feature, they nevertheless started appearing in financial magazines, and in popular newspapers; their form and purpose informed at first by editorial hunch, then increasingly by new marketing data concerning audience demographics. During the Second World War, they appeared as propaganda in cinema news reels, and in subsequent decades they started appearing in visually consistent forms, as a matter of routine in tabloid newspapers, before spreading to wider newspaper culture (certainly, this was the experience in the UK).

Early 20th-century newspaper audiences used infographics to develop bridging social capital (Putnam, 2000), in order to plan (such as line graphs that conveyed weather and barometric data, and financial data); or to develop bonding social capital (ibid.), in order to socialize (such as pictograms that conveyed trivial political information). Today, these uses and gratifications are still pertinent; albeit news audiences encounter visual data earlier in life, making use of them in more personalized circumstances, at a much more granular level and in real-time contexts, contributing to what François Hartog calls presentism, a phenomenon that seems to define modern life. Today, school children from the ages of 7–8 encounter them in the classroom when learning foundational numeracy. In healthcare, pregnant women with gestational diabetes can manage their blood sugar levels more effectively with the aid of mobile applications that displays them as real-time interactive line graphs. In the home, smart meters allow home-owners to visually measure and track the efficiency of their utility expenditure. In leisure, football fans are increasingly analysing and comparing sports performance "radars"; player by player, team by team, game by game, even by passage of play. Given these present contexts, it seems likely that data visualizations will spread to all areas of news coverage; to wherever, essentially, data become available.

Fact-checking the Future of Data Visualizations

Journalism today is in the midst of an identity crisis. This crisis is exacerbated by online mis- and disinformation, or *information disorder* (Wardle & Derakhshan, 2017) that feeds cynicism and conspiratorial thinking, as it chips away at journalistic credibility and authority. Theory is being de-coupled from a new generation of online conspiracies whose aim is not to provide an alternative explanation for events, but rather, through repetition, to undermine trust in those individuals and institutions that modern liberal democracy relies upon, in order to function (Rosenblum & Muirhead, 2019). It is becoming increasingly clear that the politicization of facts poses a grave threat to modern journalism, as it does to anyone who values the way of life liberal democracy makes possible. How can data visualization then, be a force for good in the post-truth era?

Data visualizations have served in the past to stoke scientific but also ideological dispute. For example, the hockey stick graph contained in Mann, Bradley & Hughes's (1999) report on climate change became the site of (largely ideological,

and long since discredited) criticisms about the nature of climate modelling, and by extension, the reliability of predictions about climate change more broadly. Today misleading graphs are used as a matter of routine by those engaged in organized disinformation campaigns against climate science; but they are also routinely used by a new generation of fact-checking news sites to test, and in some cases to challenge, *information disorder*. The politics of data visualization is subject to increasing scrutiny on account of their capacity to develop argumentation, and explanation (Williamson, 2016). Yet this is hardly new. Anyone familiar with the history of the form and its uses will know that they have always been ideological; they were used to express William Playfair's Pittite, liberal-Conservitism; Florence Nightingale's reforming zeal; and even Otto Neurath's hopes for a worker's revolution in Red Vienna. Data visualization is subject to ideological discourses; it cannot escape them. This will be no different in the future. As such, those who create data visualizations in our news will need to decide whether or not they are engaged in "naive empiricism" (Schudson, 1981); they will need to ask themselves whether "good" data visualizations truly can "speak for themselves", when the public views even lying demagogues as authentic, in a wider context of a crisis in political legitimacy (Hahl et al., 2018).

A Universal Language for a Future Driven by Data?

Data visualizations have often been framed as being in some way communicatively universal. They speak "all languages" (Wainer & Spence, 2005, p. 1), according to Playfair's apocryphal exchange with Louis XVI. Neurath conceived of Isotype as a "universal slang", a "universal jargon" (Burke et al. 2013, p. 89) or a "language-like technique" (ibid., p. 91) for expressing statistical truths. Infographics are a "universal language" (Funkhouser, 1937, p. 270) that seem to permit anyone to speak to everyone; an ideal communicative medium for Habermas' (1989) public sphere. In practice the earliest infographics were designed for elite, comparatively well-educated audiences. Today, new standards and principles, drawing upon journalistic and design conventions and best practices, are increasingly visible in the form of coherent *visual news values*. The BBC's Global Experience Language is an early example of this. But not all audiences are the same.

Today we live in a scientific era whose epistemic orientation towards visual evidence is defined by trained judgement (Daston & Galison, 2007). The same may be said for data visualizations arising in specialist fields. Just as medics must be trained to interpret X-ray images, so too must those developing (or using) experimental interactive visualizations of large complex data sets. This reality seems likely to influence the future forms that news infographics will take; visual journalists will face increasing divergence in their audiences' capacities and needs; they will surely incorporate more complex graphical forms that require degrees of specialism to interpret. Is there a danger, in an even more fragmented, and splintered news landscape than the present day, that these new forms may become the basis of a data visual divide; with granular, powerful, interactive explanatory forms of data

visualization for a privileged class in society, and simple, descriptive infographics for the rest? Perhaps not if present experience is anything to go by. It has been suggested that today's news audiences are not as enamoured with high-level explanatory interactives as once they were (Baur, 2017). Will data visualizations then revert to being hot, on Marshall McLuhan's terms, where once they seemed to promise so much from being cool? It is difficult to say, but the fraught economics of news, and paywalls in various guises, will surely contribute towards determining this. One thing seems for sure. In order to understand the data visualizations of the future (and those who create them), the academy will require a new generation of robust, empirical studies concerning human engagement with different formats; and audience expectations.

The Evolution of the Visual Journalist

Today's visual journalists will surely not work alone in tomorrow's newsrooms. They will continue to draw upon the specialist work of knowledge professionals more broadly. New specialist organizations will continue to contribute to our news, too. But what of professional identity? Here it is helpful to think of professionalism not just as a summation of acquired traits but also as a social process, or a struggle towards work-place autonomy (Hallin & Mancini, 2004). Today's visual journalists are clearly growing in professional status. This is visible in the emergence of relatively new (and specialist) awards, and award categories in the field; in new organizational structures within news groups that privilege data journalism, and in the rise of new social forums and community groups. It is also indirectly present in the rise of new university syllabuses, set texts, monographs and degree programmes. Visual journalists will in turn continue to draw upon standards and best practice in the sciences and social sciences; but they will also continue to draw influence from the canon of journalistic ethics. If they are to maintain their status in the newsroom, they will need to continue in these endeavours. Visual journalists will continue to draw upon participatory culture (Jenkins et al., 2009); and individuals from a range of backgrounds, working according to their own professional and organizational conventions (and pressures), will continue to inform our news. Skilled outsiders wishing to communicate visually will continue to encroach on news culture.

Conclusion

Many other questions arise, some too intractable to engage with meaningfully. Will future, sentient technology de-professionalize the visual journalist? That seems unlikely in a future economy where new ways of knowing will surely incorporate visual components, but who can say? Which formats may become most popular in the new environment? The rise of the bar chart race in 2019 serves as a marker of how certain forms, optimally functional for news audiences using social platforms, can quickly gain traction, and can effectively be applied to a range of data stories. How secure is the data visualization media environment? In some respects, today's

media are built on shifting sands. Link rot has put paid to an earlier generation of interactive graphics (such as *The Guardian*'s Tax Gap tool, from 2009). Separately, new ethical dilemmas will no doubt contribute to the personalization-privacy paradox (Aguirre et al. 2016) in news audiences' engagement with (in particular, their own) data in visual forms. And yet despite the intractable nature of some of these issues, there seems little doubt that data visualizations, whether "hot" or "cool", will continue to be a significant part of our news and media. What seems clear is that infographics and especially those professionals that produce this visual genre, will continue adapting themselves to the available technologies and tools. At the same time, these advances are supposed to establish the possible trends in fields like interactivity or the use of different narrative elements.

Note

1 https://www.srf.ch/static/srf-data/data/2018/federer/#/de

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