

Data visualization in the time of coronavirus

Júlia R. Giannella 🔟 ª * | Luiz Velho 🔟 b

^a Federal University of Rio de Janeiro, Department of Visual Communication Design: Rio de Janeiro, Brazil
^b Institute for Pure and Applied Mathematics, VISGRAF Lab: Rio de Janeiro, Brazil
* Corresponding author: <u>juliagiannella@gmail.com</u>

ABSTRACT

Currently, we observe a proliferation of data visualizations about Covid-19 in the media, which makes it a convenient time to study the topic from the perspective of different disciplines, including information design and mathematics. If, on the one hand, the abundance of such pandemic representations would already be a legitimate reason to address the issue, on the other hand, it is not the central motivation of the present discussion. The uniqueness of the epidemiological phenomenon that we are experiencing highlights new aspects regarding the production and use of data visualizations, one of which is its diversification beyond counting and visual representation of events related to the virus spread. In this sense, the article discusses, through the analysis of examples, three different approaches for this type of schematic representation, namely: visualization of hypothetical data, visualizations based on secondary data, and visualization for social criticism and self-reflection. Ultimately, we can argue that design contributes to the production of data visualizations that can help people to understand the causes and implications involved in the new coronavirus and encourage civic responsibility through self-care and the practice of social distancing.

Keywords: Communication Process, Coronavirus, Data Visualization, Information Design.

INTRODUCTION

Today, the expression "unprecedented" is heard quite often. It's as if the language we use to explain our world is falling apart and the superlatives cannot keep up with the new reality brought about by the new coronavirus pandemic. Since March 2020, our lives have been hit by an avalanche of questions that are difficult to answer: "When will this end? How can I protect myself and others? How long will schools remain closed? Am I going to lose my job?".

The irony of the situation is that these doubts emerge at a time of substantial data production, which, however, doesn't seem to be sufficient to clarify the situation. The pandemic is generating growing amounts of data such as case counts, death counts, recovery counts, testing rates, etc. At the same time, data are often uncertain, incomplete, and difficult to analyze as they are continuously reviewed and updated. Faced with the complexity and volatility of the phenomenon, scientists, journalists, and public officials strive to make data meaningful. In this sense, data visualization plays a crucial role in the communication process.

We can observe a proliferation of data visualizations about Covid-19 in the media, which makes the time very suitable for studying the topic from the perspective of different disciplines, including information design. Information design plays a crucial role in the production of effective data visualizations. Bonsiepe (2000) states that the process of communicating and sharing knowledge is associated with the presentation of knowledge and the presentation of knowledge is a central issue of design:

... without design interventions knowledge presentation and communication would simply not work, because knowledge needs to be mediated by an interface so that it can be perceived and assimilated [...] here is offered a leverage point for information design as an indispensable domain and tool in the process of communicating and at the same time disclosing knowledge. (p. 3).

The domain of design is the domain of the interface. Design acts on the interface of physical and/or semiotic artifacts by applying principles of graphic communication (gestalt, graphic semiology, etc.), usability, and a user-centered approach in project development. Ultimately, effective data visualization helps people to understand, in different degrees and aspects, the causes and implications involved in the new coronavirus and encourage civic responsibility through self-care and the practice of social distancing.

When the pandemic broke out worldwide in mid-March, maps, bar graphs, and line graphs of confirmed cases, among other types of counts, predominated in the media. However, as the effects of the crisis unfolded, the media began to pay attention to alternative types of data that go beyond the mere count of confirmed cases and mortality rates. Concepts such as probability, exponential growth, logarithmic scale, and moving average, once restricted to specialized domains, reached the daily news and needed to be incorporated into data visualization for lay audiences. At this point, we must include mathematic literacy as a second indispensable competence for data visualization production and consumption.

Perhaps, the most emblematic data visualization example that we can cite in this context is the "flatten the curve" chart that, forgive us for the double meaning, went *viral*, and gained countless adaptations. However, to talk more about this chart, we need to take a step back.

The practice and reflection of data visualization have a long history that goes back to the empirical production of maps and charts by pioneers such as Joseph Priestley, William Playfair, and Charles Joseph Minard. Additionally, we should mention the systematization itself of a theory for the visual-graphic language proposed by scholars like Jacques Bertin (2010), Edward Tufte (1983), Johanna Drucker (2014), among others. In recent years, data visualization has become popular, becoming more present in our daily experiences. Even before the Covid-19 outbreak, data visualization had already acquired a status of popularity in mass communication. Viegas and Wattenberg (2015) highlighted that "... from the perspective of journalism, is that data visualization is an essential part of this communication process. Today, a data-driven story without a chart is like a fashion story without a photo".

Today, we see it in the news (print and television), social media, textbooks, advertising campaigns, interactive dashboards, scientific studies, reports, etc. being used for different purposes: analyzing problems, communicating information, and making *evidence-based* decisions. *Evidence* is the quality of what is observable, of what gives no room for doubt. It constitutes one of the main prerogatives for the use of data-based methodologies and techniques. In this sense, time-based data visualizations are traditionally employed in two types of situations:

• Disclosure of concrete and finalized events, that is, data sets with a known beginning, middle and end;

• Disclosure of concrete and in-process events, that is, a set of data updated in realtime in a controlled environment.

None of the situations, however, describe the Covid-19 phenomenon: the pandemic, at the moment, is an event in process in an uncontrolled environment. The situation driven by Covid-19 is unprecedented both in terms of the speed and unpredictability the virus is spread and in terms of the fast pace at which news and analysis are published and disseminated in the media. The simultaneity between phenomenon and analysis of the phenomenon consolidates a new approach to data visualization. We will call this approach of *visualizing hypothetical data* that has as its focal example the "flatten the curve" chart. In this approach, data visualization moves away from its primary function, which is to evidence concrete events, to demonstrate concepts and mathematical models from data obtained in simulations.

1. VISUALIZING HYPOTHETICAL DATA

The Washington Post story signed by Stevens (2020) has as main objective to explain to a lay audience different scenarios of propagation of Covid-19. To this end, it uses charts, animations, and narrative resources. First, the article introduces the concept of an exponential curve through a chart (Figure 1) that shows the evolution of the disease in the United States between January 22 until March 13. The exponential curve behaves like an exponential function. The chart is represented on a linear scale and is effective in showing the sharp curve that depicts the rapid spread of the virus.



Figure 1. The shape of the chart is equivalent to an exponential function. Source: Stevens (2020).

The use of an icon in the middle of the sentence (Figure 2) emphasizes the typical shape of an exponential curve and reinforces the argument that if the number of cases continues to double every three days, there will be about one hundred million cases in the United States until May. Fortunately, the growth curve slowed, and the United States reached 1,761,503 confirmed cases on May 31 (CDC, 2020). A high number, however, for health system capacities.

This so-called **exponential curve** has experts worried. If the number of cases were to continue to double every three days, there would be about a hundred million cases in the United States by May.

Figure 2. The use of an icon in the middle of the sentence. Source: Stevens (2020).

In the sequence, the article strives to clarify why simulating the spread of epidemics in social distancing scenarios, according to public health professionals, is the best approach to slow down contagion and minimize the impact of the disease. To elucidate this argument, the article introduces elementary notions of dynamic systems in epidemiological situations based on the constitution of a scenario for the propagation of a fictitious disease, called *"simulitis"*. The invention of a disease to illustrate the case rather than based on Covid-19 itself is not justified. However, it can be understood as a narrative strategy to simplify the explanation, eliminating parameters not essential for an initial understanding.

The explanation of the spread of the "*simulitis*" disease is done at two levels: the first to clarify the categories of people involved in an epidemiological scenario and the second to simulate the spread in a small population.

The first level of explanation, not to mention explaining the *SIR* model (Kermack & McKendrick, 1927), the text presents the division of a given population into three categories: healthy person (equivalent to category *S*, of *Susceptible*), sick person (equivalent to category *I*, of *Infected*) and recovered person (equivalent to category *R*, *Recovered*). To clarify the contagion dynamics, the article presents two consecutive animations. The first animation reinforces the spread of viral disease through contact between a sick person and a healthy person. When a brown ball touches a blue ball, the latter acquires the color of the first, a visual metaphor for contagion (Figure 3a). The second animation shows that a sick person (brown ball) probably transforms into a recovered person (purple ball) (Figure 3b).



Figure 3. Animated graphics explaining the contagion dynamics. Source: Stevens (2020).

In the second level of explanation, the article simulates the *SIR* model in a city that is also fictitious with a population of 200 people, faced with four scenarios: a - circulation free-forall; b - forced quarantine; c - moderate distancing and; d - extensive distancing. Each scenario is communicated to the reader through an animation composed of three visual-graphic elements: 1) counting; 2) chart of change over time; 3) a simulation of contagion and recovery dynamics among individuals in the population. Figure 4a illustrates the three elements for a given moment of contagion in scenario a, that is, without any social distancing action and Figure 4b illustrates a certain moment in scenario b, that is, of forced quarantine regarding the imposed practice by the Chinese government in Hubei province, Covid-19 ground zero. The animation of the latter scenario includes a barrier that separates sick

people from healthy people, but as time passes the barrier breaks, demonstrating the impracticality of forced quarantines without a public awareness campaign.



Figure 4. Simulation in scenario *a*, circulation free-for-all, and in scenario *b*, forced quarantine. Source: Stevens (2020).

After presenting the animations, the article reinforces they are based on hypothetical data that are rendered differently each time the simulation is played again. However, there are standard shapes in the charts that are maintained (Figure 5).



Figure 5. The standard shape of the simulated charts. Source: Stevens (2020).

Specifically speaking, these charts are area charts that compare changes over time and show the proportion of the total that each category occupies at a given time. This type of visualization generates insights into general trends and relative values. Without going deeper into the analysis of the charts and the implications of each scenario, the journalist maintains that "moderate communicative distancing will usually outperform the attempted quarantine, and extensive social distancing usually works best of all." (Stevens, 2020).

The Washington Post article simplifies the complex and dynamic phenomenon of an epidemic spread. Under concrete conditions, other factors need to be considered, including the death rate from a disease that, in the case of Covid-19, is real. Except for the first chart (Figure 1) that illustrates the concept of an exponential curve based on data from a concrete and complete event, visualizations presented in the article are produced from hypothetical data based on a generic model. The approach richness to the subject is not to predict the evolution of Covid-19 for a specific country but to visualize different scenarios of the spread of an epidemic. These scenarios, in turn, are essential to understanding the concept of "flatten the curve" which became widely disseminated.

The Economist was the first mainstream communication vehicle to publish the "flatten the curve" chart to a large audience (The Economist, 2020). Published on February 29, the article features a "flatten the curve" chart (Figure 6a) by the visual journalist Rosamund Pearce and based on a chart previously created by the American agency Centers for Disease Control and Prevention (Qualls, 2017) (Figure 6b).

Giannella, J.R. & Velho, L. (2021). Data visualization in the time of coronavirus. *Strategic Design Research Journal*. Volume 14, number 01, January – April 2021. 275-288. DOI: 10.4013/sdrj.2021.141.23

Free-for-all



Figure 6. The first "flatten the curve" chart to gain visibility (a) and the original one (b). Source: The Economist (2020) and Qualls (2017).

Figure 6a is a simplified schematic representation of case counts over time. No concrete data are being mapped in this chart: there are no measurement units represented. The chart is an abstraction of curves obtained in simulations of propagation of a given epidemic, in this case, Covid-19. As we mentioned before, these simulations are created from the *SIR* model taking into account different propagation scenarios. Although the results of the simulations vary and depend on a variety of parameters, there are key trends expected for the contagion dynamics. Figure 6a shows the overlap of two curve trends for infected people. The first one, in blue and subtitled as *without measures*, has a sharp peak, indicating the coronavirus outbreak in a short period (equivalent to the free-for-all scenario). The other curve, in orange and labeled *with measures*, is smoother (or flattened), indicating a more gradual rate of infection over a long period (equivalent to the social distancing scenario).

The Economist report points out that the smoother curve results in fewer infected people at the same time, which reduces the chances of an eventual collapse of the health system resulting in fewer deaths. However, this information is only provided in the text. After its first publication in the mainstream media, the "flatten the curve" chart was adapted countless times, inside and outside the journalistic context. Barclay and Scott (2020) and Roberts (2020) adapted the chart, making it clear to a lay audience what is really at stake between a curve and another: the capacity of health systems to provide service to those in need (Figure 7). To highlight this difference, the new versions of the "flatten the curve" chart have a dotted line representing the limit of the health system capacity. Like the other elements present in the chart, the line is not mapped in terms of concrete values. The number of Covid-19 cases that will overburden the health system is not precisely known. However, the line position tangent to the flattened curve visually reiterates the argument that there is only one scenario in which the pandemic can be tackled without major risks to the population: the one of containment measures through social distance.



Figure 7. "Flatten the curve" by the Vox (a) and by The New York Times (b). Source: Barclay and Scott (2020) and Roberts (2020).

2. VISUALIZATIONS BASED ON SECONDARY DATA

There is a second wave of data visualizations that reflects the developments involved in the practice of social distance. These are visualizations based on secondary data, that is, indirectly related to the advance of the pandemic. We selected some visualizations to comment and we divided them into three axes

2.1. Socio-environmental impact

Popovich (2020) published satellite images showing the effects of the new coronavirus in Italy and China. This satellite (Sentinel-5P) detects traces of human activity –"tailpipe emissions from cars and trucks, fossil fuel burned in power plants and other industrial activities" – which can be synthesized in images, more specifically in scientific visualizations. When compared to images from the same period a year ago, this year visualization shows a significant reduction in nitrogen dioxide concentrations in Italy (Figure 8) and China (the first countries to adopt restrictive measures aimed at limiting the movement of people).



Figure 8. Each frame in the animation represents a 20-day composite of nitrogen dioxide concentrations, from mid-December to mid-March over Italy. Source: Popovich (2020).

Bakker et al. (2020) sought a similar approach by publishing a study on how the practice of social distancing is changing the mobility of people in New York. However, the nature and origin of the data are different from satellite images. The mobility data used in the visualization was provided by Cuebiq, an intelligence, and location measurement company.

The company provides anonymous records of GPS locations of users who have chosen to share their data anonymously in the U.S. from February 26, 2020, to March 25, 2020.



Figure 9. Each frame in the animation represents an average distance traveled per day by anonymous GPS users in New York. Source: Bakker et al. (2020).

2.2. Socio-economic impact

The New York Times printed edition published on March 27 (2020a) and May 9 (2020b) two visually impacting covers (Figure 10) about the wave of unemployment that has hit the United States. The two front pages use a similar strategy: they use charts on a linear scale to highlight the disproportionate peak of unemployment in recent weeks.



Figure 10. Front pages of March 27 (a) and May 9 (b). Source: The New York Times (2020a; 2020b).

Both front pages use charts to point out a correlation between the increase in unemployment in the United States and the evolution of the pandemic. By occupying the right column exclusively with data from the charts, the covers visually reinforce the intensity of the crisis:

the verticality of the column intensifies the upward or downward sharpness of the last line of the graph.

The chart on March 27 front page shows the history of weekly unemployment insurance claims in the country from the 2000s to the last week of March 2020. Data are from the United States Department of Labor. Most lines vary a few inches in height from each other. The highest previous weekly unemployment rate so far is around 600.000 during the 2008-09 recession. But that line is radically overcome by the last line that represents the dizzying increase in claims for unemployment insurance in the week of March 20-27: the line surpasses other headlines reaching the top page. The almost 3.3 million applications for unemployment insurance in this period are about five times higher than the second-highest rate.

The main chart on May 9 front page chart shows the monthly change in jobs from 1946 to April 2020. Data are also from the United States Department of Labor. When there is an increase in jobs between subsequent months, the variation is positive and is represented by a gray ascending line. When unemployment decreases, variation is negative and is represented by a red descending line. Thus, the last line – which depicts the month of April – indicates a negative variation of minus 20.5 million jobs concerning the previous month.

When creating visualizations, information designers must choose the best way to present the data, and the scale decision is one of those choices. On a linear scale, the value between the intervals on the *y*-axis is constant, which can result in sharp peaks. This type of scale has pros and cons. The disproportionality of the peaks concerning the rest of the charts corroborates the tone and voice of the headlines, which is to highlight the seriousness of the crisis.

Data, however, are not neutral units of information, and questioning them is a critical attitude. Yglesias and Animashaun (2020) share some considerations on the data used to address the current unemployment problem. On the March 27th front page, we can argue that the increase in unemployment insurance claims in the U.S. has increased dramatically in recent weeks not only because of possible layoffs but also because a law recently enacted in the country has expanded the eligibility of beneficiaries. At the same time, unemployment insurance claims are likely to be underreported because the state systems responsible for receiving requests do not support the high demand for claims. This leads to the belief that the actual number of requests exceeds that registered by official agencies.

On the May 9th front page, we can consider the fact that the monthly change in unemployment is measured in absolute numbers. If it was based on the unemployment rate, would the chart shape have the same visual strength? The NYT itself ponders this aspect by bringing a secondary chart to the front page (Figure 11). It shows the unemployment rate in the same period. The unemployment rate in April 2020 is the highest recorded in history, but showing numbers summarized in rate is less visually impacting than presenting the variation in absolute numbers.

NATIONAL UNEMPLOYMENT RATE



Figure 11. Monthly unemployment rate in the U.S. from 1946 to April 2020. Source: The New York Times (2020b).

2.3. Consumer habits

Leatherby and Gelles (2020) provide an analysis of how the virus profoundly changed lives in the U.S., including the way citizens spend their money. The first visualization (Figure 12) is a historical series that illustrates the percentage change in spending by category between January 8 and April 1. There is a clear drop in expenses in all categories, except for groceries – which includes expenses in supermarkets, convenience stores, among others. Besides, the sharp growth curve in groceries in early March coincides with the time of supermarkets crowded in the country, when the American population, incited by panic, emptied shelves in numerous establishments.



Change in credit and debit card spending

Figure 12. The chart shows the percentage change in spending. Source: Leatherby and Gelles (2020)

The second visualization (Figure 13) is a bubble chart that shows the variation in spending by sector between the week ending April 1 and the same period in 2020. The bubbles areas are sized by the sector's sales and the colors represent whether the variations are negative (in orange) or positive (in green). It is easy to spot that airline and movie theaters are strongly impacted while gaming and online grocers are experiencing strong growth.



Figure 13. Change in spending from 2019 for the week ending April 1. Source: Leatherby and Gelles (2020).

3. SOCIAL CRITICISM AND SELF-REFLECTION

There is a third wave of data visualizations leveraged in the context of the pandemic. We are experiencing a health crisis that produces enormous amounts of data that, in turn, are processed and released almost in real-time. However, these data, even when visualized, are not able to address all doubts and alleviate our anxieties.

D'Ignazio (2015) draws attention to the fact that we need to invent new ways of representing uncertainty, outward looks, missing data, and defective methods:

While visualizations – particularly popular, public ones – are great at presenting wholly contained worlds, they are not so good at visually representing their limitations. Where are the places that the visualization does not go and cannot go? Can we put those in? How do we represent the data that is missing?

In this perspective, data visualization practices arise guided by other motivations. We can mention, on the one hand, examples that promote social criticism and care for the community and, on the other hand, typical cases that provide self-reflection.

3.1. The unequal effects of the pandemic

Through data visualization practices aimed at social criticism and community care, we want to emphasize examples that demonstrate the disproportionate impact of Covid-19 on the most vulnerable segments of society. The contribution of the former data journalist from The Guardian, Mona Chalabi, is significant in this direction. Mona has a unique style and approach to communicate data: her hand-drawn visualizations expose the inaccuracy of the data, point out social wounds, and challenge common sense.

In the context of the new coronavirus, Mona developed a thematic series with about 20 visualizations on the subject. The series was shared on her profile on Instagram (Chalabi, 2020). Figure 14 depicts a selection of three data visualizations that show the greater vulnerability of refugees, blacks, and prisoners in the face of the pandemic.



Figure 14. Hand-drawn visualizations by Mona Chalabi. Source: Chalabi/Instagram.

3.2. Self-reflection and expression

For data visualization practices aimed at self-reflection and expression, we want to highlight a more paradigmatic change in the flow of data visualization production during the pandemic. So far, we have cited data visualization practices produced by the media (official or alternative) to clearly and reliably inform a wide audience. In addition to this purpose, the Covid-19 context highlights the emergence of data visualizations created for other purposes such as self-reflection and expression. Along these lines, initiatives such as *Diario Visual de la cuarentena* (Errea, 2020), *Data Selfie da quarentena* (Giannella, 2020), and *Quarantine portrait* (Massimetti & Testa, 2020) use data visualization as a tool to reflect on and represent everyday life during the period of social distancing. *Data Selfie da quarentena* was an online workshop offered for students of the Communication Design Course at UFRJ during the momentary shutdown of teaching activities due to the Covid-19 pandemic. Inspired by the Dear Data project (Lupi & Posavec, 2015), the workshop aimed to encourage the participant to reflect on the quarantine period from the collection, representation, and communication of personal data that constituted the background of their activities during isolation.

Figure 15 is an example of a data selfie designed by a student. The representation portrays a week of the nostalgic feelings felt by its author. The horizontal line represents that specific week, starting on Monday (*Segunda*) and ending on Sunday (*Domingo*). The color variation represents the two nostalgic categories: red depicts nostalgia of outdoor activities; blue of indoor ones. The up and down orientation of the line represents whether or not the student spoke about that feeling she was having. Finally, the height of the line indicates the intensity of the feeling (low, medium, high).

Giannella, J.R. & Velho, L. (2021). Data visualization in the time of coronavirus. *Strategic Design Research Journal*. Volume 14, number 01, January – April 2021. 275-288. DOI: 10.4013/sdrj.2021.141.23

UMA SEMANA DE SAUDADE



Figure 15. A visualization of personal data that expresses a week of missing. Source: personal archive.

4. CONCLUSIONS

Crises like a pandemic require abundant and consistent communication with reliable sources. Also, due to its complex and data-based nature, the phenomenon requires visual communication. Different agents take on the mediation of the communication process, including designers. Media – from mainstream vehicles to academic publications and independent initiatives – must be judicious and sensible when selecting and structuring data about Covid-19. Data visualizations are powerful resources for communicating information, but when misused they can deceive and misinform.

In this article, we seek to highlight the contribution of design in the process of producing data visualizations that inform, clarify and, express multiple nuances and facets of the representation of the new coronavirus. Through exploratory research, we selected and analyzed examples of data visualizations that characterize its diversification beyond count events. Without exhausting the subject, the research points to possible future works.

Covid-19 exposes challenges for the visual representation of data: how to explain and describe exponential growth in a clear and accessible way? How to correctly compare the spread of the virus in different countries? How to visually explain uncertainty in numbers such as counting cases when the tests performed are not always sufficient to make them reliable indicators of real cases? Rather than reducing the complexity of the phenomenon, data visualizations should embrace visual conventions specific to the context, as well as making use of annotations, narrative strategies, and caveats.

REFERENCES

Bakker, M. et al. (2020). Social Distancing in New York City. *MIT Media Lab*. Retrieved 11 May, 2020, from http://curveflattening.media.mit.edu/posts/social-distancing-new-york-city/.

Barclay, E., Scott, D. (2020). How canceled events and self-quarantines save lives, in one chart. *Vox.* Retrieved 11 May, 2020 from <u>https://www.vox.com/2020/3/10/21171481/coronavirus-us-cases-quarantine-cancellation</u>.

Bertin, J. (2010). Semiology of Graphics: Diagrams, Networks, Maps. USA, California: ESRI Press.

- Bonsiepe, G. (2000). Design as tool for cognitive metabolism: from knowledge production to knowledge presentation. In: *Proceedings of International Symposium on the Dimensions of Industrial Design*. Milan: Politecnico di Milano. Retrieved 28 October, 2020, from <u>http://www.guibonsiepe.com/pdffiles/descogn.pdf</u>.
- CDC (2020). Cases in de U.S. Retrieved 2 June, 2020, from https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/cases-in-us.html.
- Chalabi, M. (2020). *Instagram profile*. Retrieved 2 June, 2020, from <u>https://www.instagram.com/monachalabi/</u>.
- D'Ignazio, C. (2015). What would feminist data visualization look like? *MIT Center for Civic Media*. Retrieved 28 October, 2020, from <u>https://civic.mit.edu/feminist-data-visualization</u>.
- Drucker, J. (2014). *Graphesis: Visual Forms of Knowledge Production*. USA, Cambridge: Harvard University Press.
- Errea, J. (2020). *Diario Visual de la cuarentena*. Retrieved 2 June, 2020, from <u>http://www.cuarentenavisual.com/</u>.
- Kermack, W. O., McKendrick, A. G. (1927). A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society of London Series A*, (115): 700–721. DOI: /10.1098/rspa.1927.0118
- Leatherby, L., Gelles, D. (2020). How the virus transformed the way American spend their money. *The New York Times*. Retrieved 11 May, 2020 from https://www.nytimes.com/interactive/2020/04/11/business/economy/coronavirus-us-economy-spending.html.

Lupi, G., Posavec, S. (2015). Dear Data. Retrieved 11 May, 2020, from http://www.dear-data.com/.

- Massimetti, M., Testa, A. (2020). *Quarantine Portrait*. Retrieved 2 June, 2020, from <u>https://quarantineportrait.art</u>.
- Popovich, N. (2020). Watch the Footprint of Coronavirus Spread Across Countries. *The New York Times*. Retrieved 11 May, 2020, from <u>https://www.nytimes.com/interactive/2020/climate/coronavirus-pollution.html</u>.
- Qualls, N. (2017). Community Mitigation Guidelines to Prevent Pandemic Influenza—United States, 2017. MMWR. Recommendations and Reports, 66. DOI: <u>/10.15585/mmwr.rr6601a1</u>
- Roberts. S. (2020). Flattening the Coronavirus Curve. *The New York Times*. Retrieved 11 May, 2020, from https://www.nytimes.com/article/flatten-curve-coronavirus.html.
- Stevens, H. (2020). Why outbreaks like coronavirus spread exponentially, and how to "flatten the curve." *The Washington Post*. Retrieved 11 May, 2020, from <u>https://www.washingtonpost.com/graphics/2020/world/corona-simulator/</u>.
- The Economist. (2020) *Covid-19 is now in 50 countries, and things will get worse*. Retrieved 11 May, 2020, from https://www.economist.com/briefing/2020/02/29/covid-19-is-now-in-50-countries-and-things-will-get-worse.
- The New York Times (2020a). *27 March front cover*. Retrieved 11 May, 2020, from https://static01.nyt.com/images/2020/03/27/nytfrontpage/scan.pdf.
- The New York Times (2020b). *9 May front cover*. Retrieved 11 May, 2020 from https://static01.nyt.com/images/2020/05/09/nytfrontpage/scan.pdf.

Tufte, E. (1983). The Visual Display of Quantitative Information. USA, Cheshire: Graphic Press.

- Viegas, F., Wattenberg, M. (2015). Design and Redesign in Data Visualization. *Medium*. Retrieved 28 October, 2020, from <u>https://medium.com/@hint_fm/design-and-redesign-4ab77206cf9</u>.
- Yglesias, M., Animashaun, C. (2020). US rocked by 6.6 million more initial unemployment claims last week. *Vox.* Retrieved 11 May, 2020, from

https://www.vox.com/2020/4/9/21213449/unemployment-initial-claims-us-april-4.

Giannella, J.R. & Velho, L. (2021). Data visualization in the time of coronavirus. *Strategic Design Research Journal*. Volume 14, number 01, January – April 2021. 275-288. DOI: 10.4013/sdrj.2021.141.23